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THE STORY

OF THE

PEASANT-BOY PHILOSOPHER:

OR,

"A CHILD GATHERING PEBBLES ON THE SEA SHORE."

(FOUNDED ON THE EARLY LIFE OF FERGUSON, THE SHEPHERD-BOY ASTRONOMER, AND INTENDED TO SHOW HOW A POOR LAD BECAME ACQUAINTED WITH THE PRINCIPLES OF NATURAL SCIENCE.)

BY

HENRY MAYHEW,

AUTHOR OF "LONDON LABOUR AND THE LONDON POOR."

"I am but as a child standing on the shore of the vast and unexplored Ocean, and playing with a little pebble, which the waters have washed to my feet."

Saying of SIR ISAAC NEWTON.

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TO

LITTLE ATHOL,

IN THE HOPE THAT IN AFTER YEARS IT MAY BE THE

SOURCE OF SOME KNOWLEDGE AND

HAPPINESS TO HIM,

AND INSPIRE HIM WITH A TASTE FOR THE STUDIES OF

WHICH IT TREATS

This Work is Dedicated,

BY HIS FATHER.

PREFACE.

This book, though *founded* on the early life of Ferguson, makes no attempt at re-presenting either the circumstances or scenery amid which the "Shepherd boy" passed his youth. To have done this, would have been to have written a biography of the young astronomer, in which the character and incidents must have been literally followed. Such a work faithfully executed would doubtlessly have been sufficiently interesting and instructive, but it would have involved a more intimate knowledge with the facts of Ferguson's boyhood than the materials left us could possibly have supplied. Moreover, the object of the author was not so strictly to teach, as to create in youth a *taste* for learning—it was to appetize rather than to "cram,"—to excite a craving that would stir the young mind to seek its own food, instead of accustoming it to be, as it were, "stall fed."

It has long appeared to the author of the present

work that the prevailing system of education induces merely the same state of obesity intellectually, as the modern bucolic mode of feeding does physically—those who win the prizes at our Universities being generally as remarkable for the enormous *capacity* and inactivity of their minds as the competitors at Baker-street are for those of their bodies; the one gorged with learning, the other with oil cake, but each alike ponderous and powerless, and both having little or no health or vigour in them.

The entire art of teaching lies in the excitation of attention to the subject to be taught; but there are two distinct kinds of attention, and according as one or the other of these is appealed to, so does the mind become vigorous or enervated. We can attend to a subject either *passively* or *actively*. In the former case, the mind is put into a state of *dream*, by the excitement of some vivid emotion, or "interest" as it is called, in connexion with a certain subject, and is so thrown into a disposition to receive such ideas and facts as one may wish to impress upon it. This constitutes, so to speak, the dramatic art of teaching, and the power of the novelist and the playwright often affords us striking instances of it; for, by such means, hundreds of diverse minds and natures are frequently held enchained as it were, for several hours, to the same subject, and the trains of thought made to flow on

continuously, in one and the same direction, among a number of different individuals.

Bishop Butler (in his "Sermons on Human Nature"), and many others after him, have long since remarked, and speculated as to the causes, concerning the ill effects which arise from an inordinate habit of indulging in what is termed sentimental literature. The philosophic preacher at the "Rolls Chapel" refers the injury done to the mind by continually reading romances and "love stories," to a breach of the moral law which connects the exercise of charity with the excitation of a feeling sympathy in our natures. The author of the present work, however, believes the harm done in such cases proceeds more from an intellectual defect than a moral one—viz., by inducing a habit of mere *passive* attention, or, in other words, encouraging a state of constant dreaming, and thus incapacitating the mind for the least exertion on its own part; so that the intellectual faculties become at length enervated and sickly (for such is the invariable effect of a want of exercise—mentally as well as corporeally), and when the individual has to study any subject that requires some effort in order to be comprehended, the sense of labour involved in the task is either so repulsive that he shuns it altogether, or else, in attempting it, he is overpowered with fatigue after two or three moments of continuous attention.

The faculty of *passive* attention is that of mere

receptivity — or *ac*quisitiveness, as contradistinguished from that of *in*quisitiveness; and such is the capacity of some minds in this respect, that they may be crammed with any amount of knowledge, though, after all, they will be learned rather than wise, lacking the power to apply their information with any profit to themselves or others, and being only intellectually corpulent instead of intellectually strong.

The faculty of *active* attention, however, gives widely different results. It is this faculty which distinguishes our dreaming from our waking moments. In sleep, the mind can only follow the train of fancies induced in it—for it has not the power to guide or stop them,—so that no person reproaches himself for his impulses or thoughts at such times. When we are awake, on the contrary, we are conscious of the ability to direct the current of our ideas as we choose; we know we can single out, from the crowd of conceptions that are continually hurrying through our brain, any one that pleases us,—that we can detain it while we examine its several relations, and that we can induce a long train of other conceptions in connexion with it. In a word, we are aware that in our waking moments we can be the *masters* of our natures, rather than the *slaves* of them, as we are forced to be while dreaming. To doubt the existence of the faculty of active attention, would be to doubt our own consciousness; for

we feel, when we read a difficult problem in Euclid, that each step requires a severe mental effort to prevent our thoughts rambling from the reasoning, and of this effort we have the same sense,—there being the same feeling of fatigue connected with it, when long protracted,—as when we voluntarily exert our muscular strength.

Now the misfortune is, that the sense of mental effort connected with the exercise of active attention is often so irksome to naturally weak or young minds, (for the faculty does not appear to be developed till the age of fifteen years), that the study of such matters as require the intellect to be *exerted* for their comprehension, becomes uninviting and tiresome to the student. So beautifully, however, is the mental machinery arranged, that this feeling of tiresomeness is felt only at the first exertion of the faculty; for after a time, the wonderful mental principle of habit comes into play, by which, acts that were originally irksome, become, by the frequent and regular repetition of them, not only pleasant to us, but positively irksome if not indulged in. Hence the educational problem is, how is a habit of active attention to be engendered in the mind; or rather, how can the feeling of irksomeness which ensues on the first exertion of the intellect be so far removed that the youth may not, by the dread of the labour, be repelled from the study of those subjects, the comprehension of which

is not alone necessary for the expansion of the mental faculties, but a source of much refined pleasure, as well as being likely to prove of considerable benefit to the student, and perhaps to mankind in general.

There are several ways of attaining this end. Those generally practised are of an artificial character, and consist in attaching either some extrinsic reward or punishment to the performance or non-performance of the task. The *natural* and intrinsic method, however, appears to be by far the most easy and sure. This consists in exciting the *taste* of the youth towards the subject to which the attention is required to be given. By a taste for a particular pursuit, we mean solely a permanent desire to attend continuously to the same subject; so that the tastes of an individual are, as it were, the mental forces that move and direct the current of his thoughts into a particular channel.

To create a taste for a certain pursuit, it seems to be essential that the individual should be made to experience a vivid sense of pleasure in connexion with it. Sometimes this pleasure appears to be due to some delicate organic arrangement, as in persons having a natural "turn," as it is termed, for music. It often, however, proceeds from the excitation of the feeling of wonder and admiration in the mind. Such was the case with the boy Ferguson, on seeing his father raise the roof of his cottage by means of a lever. This was the cause of that taste for

mechanics which marked "the Shepherd's" whole life. So again with Chatterton, who, we are told, could not be made to learn his letters till the illuminated characters of an old manuscript had taken his fancy, and excited that taste for ancient literature which never left him in after years. Many other such instances might be cited to show that the excitation of a vivid feeling of delight in connexion with a particular subject, has shaped the thoughts for an entire existence.

Taste is indeed always self-educational; once developed, the trouble of tuition is saved us, for then the mind is bent on acquiring the knowledge for itself, instead of having to be crammed with it by others. Moreover, the analysis of our own emotions teaches us that the feeling of curiosity, or the desire for knowledge in connexion with any subject, is but the consequence of that state of perplexity or mental uneasiness which arises in the mind whenever anything strange or wonderful has been brought under our notice, and we are unable to divine either the cause or the nature of it. This feeling of curiosity—the craving for information, which thus comes upon us,—may be but of short duration, but, on the other hand, the emotion of beauty (if associated with the wonderment) tends to give considerable permanence to the desire. Admiration necessarily causes the mind to dwell upon the object exciting it—the natural tendency of the

emotion being to detain the thoughts and fix the attention to one point, so that the entire train of ideas which rises afterwards is governed by it, and everything that subsequently forces itself on the notice, serves only to suggest some conception in connexion with that which originally induced the feeling.

The excitement of the taste, then, is not only the first and easiest, but it is likewise the most natural and enduring guide to knowledge. To excite a taste in youths for natural science, by means of the feelings of wonder and admiration, is the main object of the present book. It has not been a work lightly undertaken or arranged without deliberation; and the author while seeking to impress boys after leaving school with a love of natural philosophy, has striven to impress them also with a sense of some of the higher truths that lie beyond the province of mere "physics." As an instance, he would direct attention to the chapter entitled "The First and Last Law," observing, that the arguments there employed concerning the eternal duration of the spiritual force, are, to the best of the writer's belief, so employed for the first time.

H^{y}. M.

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CHAPTER XX.

THE STORY

OF THE

SHEPHERD-BOY PHILOSOPHER.

CHAPTER I.

THE FIRST GLEAM OF LIGHT.

IT was a busy day at Davy Evans's. Little Owen—the younger of his two sons—was up betimes, for he had heard his father say that he meant to lift the roof of his cottage that morning, and the boy had been wondering half the night through how such a feat were possible.

His father—the lad had thought to himself, as he lay in his bed, with his eyes fixed on the stars that twinkled through the lattice—his father was not a young man; he'd been grey as long as he could remember him. Nor was he near so strong as John Jarman, the blacksmith; and not even he—no, nor ten like him—could raise the thatch of

their cottage "the least scrap"—Owen was sure of that!

Often—mused the thoughtful boy in the depth of the night (it was long past midnight, he knew, for he had heard the heavy wagon go rumbling along the road on its way to town)—often, when he had been up among the rafters watching the martins fly in and out to feed their young, had he noticed that the beams were as thick as his body; besides, there was such a number of them running lengthways and sideways under the thatch, so that how could his father ever lift them all?

Why, sometimes—so ran the current of his wakeful dreams—he had carried his father's dinner for him to the spruce plantation, when he had gone there to fell some of the tall trees for the squire, and the two of them together had been forced to use a handspike to move even the smallest of the trunks along the ground.

"How, then," Owen would ask himself again and again, "*can* it be possible for father to lift the trunks of so many trees as there are in the rafters of our cottage?"

But, though Owen kept on doubting, half the night through, the ability of his parent to execute the task he had set himself, the idea of doubting that his father intended to *try* and do as he had said never for a moment entered the lad's brain.

Owen had never in his life thought of questioning

his parent's word, for he was instinct with that confiding faith which is one of the marked characteristics of the young. Indeed, Davy Evans had taken especial pains to impart in the minds of all his children, from their earliest age, a high reverence for truth. It was one of the honest man's chief delights to point out to his lads how all men—even the wisest—knew more things by faith than they could ever acquire for themselves by experience.

"Suppose," he would argue to his boys, "that we had doubted all men's words, what a world of mistrust and suspicion it would have been, and how little progress could we have made in anything. The greater part of our lives then would have been taken up in procuring evidence of the truth of what was said to us. Why," he would say, "we should have had to travel over the whole world before we could have put trust even in a simple book upon geography. We should have had to visit every foreign land before we could have credited its existence. But now, by the principle of faith, we sit at home by our fireside, and by our reliance on the words of others have the same assurance of the reality of countries thousands of miles away from us as if we had visited them ourselves."

"Think," he would add, "of the vast amount of faith that is exercised by people in the reading of an ordinary newspaper. What a multiplicity of events are there recorded. Why, to credit the history of a

single week, or even a day, now, requires as great a stretch of belief as does the history of past centuries. So true is it that man depends more upon faith for the cultivation of his intellect and affections, than perhaps upon any other principle of his nature."

"Now, faith," Davy Evans would conclude, "depends upon truth-speaking. Had all men, or even the greater number of men, indulged habitually in falsity, we should have been as generally distrustful as we are now confiding. He, therefore, who tells a lie attempts to undermine this principle of trust in men's words, and so to deprive us of a means of knowledge and a source of happiness without which we should be worse than savages."

Davy Evans was a man essentially of good common-sense; indeed, he had no other guide in all he did or said, for such faculties as he possessed had never received the least development from the education of others. All he knew he had taught himself.

Davy was precisely one of those minds which are termed ingenious. He could do almost anything for himself. Though a mere day-labourer, he was a bit of a blacksmith—a tolerable carpenter—and sufficient of a mason to build a rough garden-wall, or a cow-house for his neighbours. He could cobble his own boots, and mend his donkey's harness, and use the needle well enough to patch his own clothes. He could solder a bit too, (the saucepans, the tea-kettle, and the bright tins over

the mantelpiece, all bore evidence of his handiwork); and he had fitted up an old turning-lathe in a shed he had built beside the pig-sty, where he delighted to fashion tobacco-stoppers for his friends, and nine-pins and wooden dolls for the little ones in the village.

There was scarcely a trade, indeed, to which Davy could not turn his hand. To be sure, he excelled in none; but that was hardly to be wondered at; and, to say the truth, though Davy's mind was sufficiently quick to acquire a slight knowledge of almost anything, it was not sufficiently patient and persevering to arrive at perfection in any one subject or handicraft whatever. Had it been otherwise, Davy would have been a great man rather than a clever one.

The best friend Davy had met with was Mr. Wynn, the minister of the little parish of Llanvach. From this gentleman Davy had the loan of all the books with which he had made himself acquainted. The living of Llanvach, however, was not sufficiently lucrative to admit of its minister's library being very extensive. But luckily for Davy, it contained, among a very few books of a secular character, an old copy of Rees' Cyclopædia; this, giving as it did a short though antiquated account of almost every point of knowledge, exactly suited the inquisitive mind of Davy Evans; and thus the self-taught day-labourer had,

in his leisure, informed himself with what is termed a "smattering" of facts on an infinite variety of subjects.

Owen had such confidence in Davy Evans' powers, that, boy like, he thought his father could do almost anything. He had stood beside him at the lathe for hours, and with his eyes riveted to the mandril, watched him turn the ugliest and roughest pieces of wood into the most beautiful forms. He had blown the bellows of the blacksmith's forge for his father when he had got leave to use it for an hour or two after his day's work was over, and he had seen him with the sparks playing about him like a fountain of fire, fashion a pair of shoes for old Jack (their donkey), out of some rusty, broken door-bolt. He had sat on a stool at his father's feet, and looked up at him all the while he mended the bellows of some toy poodle-dog he had to make bark again, or repaired some pasteboard tumbler, worked by sand, for the little Squire Williams, on the other side of the river.

These, and a hundred other such instances of skill, together with the character Davy had throughout the village of being the handiest man for miles round, had impressed the lad with a notion that his father was sufficiently clever to accomplish anything he chose to undertake.

"Your father ain't so clever as mine," he would say to the other boys of the village, as they

stood in a cluster looking over the little bridge beside the water-mill, bragging of the deeds of their several families.

There was, therefore, no reason for Owen to doubt Davy's lifting the roof, save and except that he couldn't understand it; and it was simply because the boy was inwardly convinced that his father *would* lift it, and because he couldn't, for the life of him, comprehend by what means he was to do so, that the lad had been tossing about in his bed half the night through, cudgelling his brains in the vain hope of discovering the process by which the wonderful feat was to be achieved.

Well, as we have said, Owen was up betimes. There was not a creature to be seen abroad, as the boy thrust back the iron-frame of his little lattice, and stretching out his neck, looked up and down the straggling double row of cottages beside the river Wye, that made up the little village of Llanvach. Not a living thing was to be seen save "old Jack," the donkey, posted beside the doorway, with his head hanging down almost to his knees, waiting patiently for the bit of bread that was always handed out to him at breakfast-time; and as the knowing brute heard the metal frame jingle while Owen hooked it back, he raised his head and ears, and saluted the boy with a bray of delight.

Owen knew it was early, for though he thrust his

head far out and put his hand beside his ears, he could not catch the sound of the throbbing of the neighbouring clothier's water-wheel. All he could hear was the hum of the distant falls of the river, which was still pinky with the first rays of the morning sun, and steaming with the mists that went winding round the base of the opposite mountain, and floating wavily upwards, like a thin white scarf, in the breeze. Then, as he cast his eyes aloft to the peak of "Garth," as it was called, he beheld its verdant sides glitter on the higher rays of the sun, green and golden, like a peacock's back.

Presently the boy darted off to the window at the other end of the room, and as he peeped out towards the common that sloped high up behind the house, he knew by the round black clouds of smoke that came rolling thick and fast from the chimney of the blacksmith's forge, that young Jarman was stirring; so, seizing his cap, he hurried down stairs, with his boots in his hand, lest he should disturb his father before the time of rising.

As the lad undid the fastenings, and drew back the upper half of the little parlour door that opened into the road, the donkey, roused once more by the grating of the bolts, thrust his head over the hatch, and stretching his neck as far as possible into the tiny room, rubbed his soft velvety nose against the cheeks of his young master, whilst the boy was busy, down on one knee, lacing his boots.

But Owen's mind was too full to notice the affectionate beast otherwise than by an instinctive pat or two, so he stayed not to hug him and chatter to him as was his wont, but hurried off towards the blacksmith's with old Jack capering playfully after him, more like a huge dog than a creature with hoofs to his heels.

It was not long before Owen had communicated to the blacksmith's boy the feat that was about to be accomplished at their cottage that morning, but young Jarman, who was the biggest of all the boys in the village, and consequently a small oracle, as well as a bit of a despot among them, no sooner heard the news than he turned on his heel and commenced patting down the fire of the forge he had left to listen to Owen's tale. Presently, seizing the handle of the bellows, he said, as he made the fire roar again with his strokes, and the red hot coal-dust spurt up like a miniature volcano, while the cheeks of the boys and the beams and walls of the building grew suddenly crimson with the glow,—"Oh, ah, I dare say! *your* father's so clever he can do anything—*you* think he can! But he an't half so strong as *my* father. Why, I've seed mine bend a poker across his arm, and lift that there hammer—just you feel the weight of it now—up in his teeth. And yet he'd never be such a silly as to go and try and lift a roof."

Then suddenly the bent cow's horn that served for

a handle to the lever of the bellows, flew upwards, released from his hand, and the grimy boy seated himself on the anvil and commenced swinging his legs backwards and forwards as he looked knowingly in Owen's face. "Better come with us fishing, Owey," he exclaimed; "father knows where there's such a jolly salmon—such a whopper—he says as he thinks it's this year's fish. He seed him yesterday lying under a shelf of rocks, a goodish bit up above the ferry. He's a going to make a spear, afore he starts this morning, so that if the thing wont rise to the fly, he'll have him that way anyhow. You'd much better come now!" and then putting his legs straight out, and rolling his long, dirty leathern apron round his waist, the young blacksmith gave himself two or three twists round on the bright smooth top of the anvil.

"Oh, I say, Owen!" he cried, as he stopped short, "if you'll only come now, I'll show you such a plummy blackbird's nest, chock full of young uns, and just ready to fly. It's all on our way home, and I don't mind shinning up the tree to get it. You shall go halves if you'll come with us,—there now. I've had my eye on that there nest ever since it was first built. The mother's as big and black as a crow. If I hadn't a shinned up the tree when I watched her off the nest, and seed as she'd got four eggs of her own, I should have picked her off a long while since with my crossbow. Ah, an't that a

beauty of a bow if you like; *your* father, Owen, don't make you such things as that, though he *is* so clever as you say. Oh, what do you think, Owen?" cried the rough-headed lad, as he began balancing the heavy sledge hammer on the palm of his hand; "I shot such a bouncing bat with my bow, in the dingle, last night. You wait there, and I'll run and fetch it you."

Young Jarman jumped from the anvil, and coming over to his little visitor (who stood, still leaning against the door-post, with his cheek pillowed on his palm), put his bare, smudgy arm round the boy's neck, as if to make friends with him—for he could see the lad was vexed at the taunts he had uttered about his father; and he said, as he leant his head on Owen's shoulder and looked in his face, "You'll come with us, Owey, won't you now? Oh, it'll be *so* prime with you there! Father's going to take a lot of bread and cheese and beer, and we're to have our dinner on the rocks with some of the young chives that's just coming up there. Don't you like 'em, Owen? Don't *I* just—that's all!" and the youthful Jarman drew his breath in between his teeth, and rubbed his tawny hand up and down his leathern apron.

"Say you'll come, now, there's a good old cock," he continued, in a coaxing tone, as he patted Owen on the cheek. "And oh, I'll tell you what—there's some gipsies on the other side of the river, just past the ferry. Shouldn't I like to be off with them for

a month. Or, I say, Owen, if you'd only go with us, wouldn't I cut right away to sea, that's all. I can't abear this beastly life—a broiling over this here filthy forge all day—and I won't stand it much longer, neither—not I."

During this speech, the young blacksmith had instinctively picked up a piece of rusty iron, and, as he came to the latter part of it, he vented his indignation by jerking the heavy piece of metal at the ribs of the donkey that stood waiting for his young master at some little distance outside the forge.

This was more than poor Owen could bear. He had long been burning with rage, the blood tingling in his ears, and his hands and teeth clenched tight with suppressed passion to hear his father sneered at by the young blacksmith; but when he saw the poor beast whom he loved with all the ardour of a gentle-hearted youth for some pet animal, scamper off, writhing with the pain of the heavy blow, he lost all thought of the difference between the ages of himself and young Jarman, and, seizing one of the smaller hammers that lay on the ground at his feet, he flew towards the tormentor of the patient brute, half mad with fury and revenge, and eager to deal on him a heavier blow than he had inflicted on the unoffending animal.

Jarman no sooner saw Owen stoop to raise the weapon than he fled round the shop, pursued by the boy; and round and round they ran, till Owen, tired

with the chase, and his passion half-spent in the energy of his own exertions, flung the hammer from him and darted from the place, saying, as he shook his fist at the blacksmith's boy, "You shall be sorry for this, still, John Jarman."

Owen hastened as fast as his remaining strength could carry him to the top of the hill whither the poor old Jack had fled, and there he found him, striving to lick the blood that streamed from the wound in his side.

The generous boy no sooner caught the poor brute in his arms than he hugged him fondly to him, the tears streaming the while from his eyes; and as Jack lifted his head and rubbed it against his young master's cheeks, Owen vowed silently he'd so excel young Jarman for the future, that in after life the fellow should hear his praises sounded by every one. "Some," inwardly resolved the lad, "shall tell him how clever I am; some shall talk to him of my goodness. And oh! if I only could make my name known all over the world the same as those great men I've heard father read about—and many of them have been at first nothing but poor boys like me—then go where he would he'd hear some one speak well of me. Father says nobody knows what they can do till they try. And I *will* try—yes, *that* I will, Jack," he said, talking to the donkey. "I'll learn and learn, and then, if John Jarman's bigger than I am now, I shall one day be his master in

everything. Who knows but I may be a fine gentleman, while he's only a poor man still."*

The reverie of the youth was interrupted by the struggles of old Jack to get his head back to the wound in his side, for Owen had still his arms clasped round the animal's neck, and his head resting on his mane. "Poor old thing," he exclaimed; "I forgot you were in pain all this while. Come along to the hedge-side," he continued, talking to the donkey as usual, as if he understood every word he said. "We'll get some water there, old fellow, and wash the wound nicely for you. Come along, Jack! come!"

When Owen had led the animal to the little mountain stream, he knelt down on the logs that served for a foot-bridge across it, and, stationing the donkey by his side, commenced scooping up the

* The reader is referred to an incident of a similar kind to the above in the life of Sir I. Newton:—"An accident, we are told, first fired him to strive for distinction among his companions at school. The boy who was immediately above him in the class, after treating him with a tyranny hard to bear, was cruel enough to kick him in the stomach with a severity that caused great pain. Newton resolved to have his revenge; but of such a kind as was natural to his reasoning mind even at that early age. He determined to excel his oppressor in his studies and lessons; and setting himself to the task with zeal and diligence, he never halted in his course till he had found his way to the top of the class."—The Boyhood of Great Men.

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water in the palm of his hand, and bathing the wound for the grateful brute, the lad chattering all the while to him.

"There, isn't *that* nice?" he said, "isn't *that* nice, old boy? What a shame to hurt a good, kind old thing like you! Father often says you're more knowing than a good many people in the world. Ah, you're a cunning old rascal, Master Jack, that you are! Who, when he goes to market, will only go into town one way, so as to pass the chemist's shop, and get some peppermint-drops given to him? Never was there such a fellow for peppermint-drops as you Jack! And *ain't* you a knowing old thing about breakfast-time? Why, when it's pitch-dark in the winter, and we're having our meal by candle-light, afore father goes to work, *you* know when it's six o'clock, you do, you rogue! as well as if you had got a silver watch round your neck, like young Squire Williams, over at the Court, there. Then you're so sly, you are, rubbing your old nose first against the window panes, and then banging your hoofs against the door, to let us know you're outside. Catch *you* going away without your couple of slices of bread—and who likes treacle, you old rascal, eh? Don't you rub your head up and down me finely, if I give you a bit? Oh, you're a deep old gentleman, you are, Jack! Why, I believe you'd know the sound of father's and my foot anywhere. Look when father's out late working, and we come down the

common sometimes when it's so pitch-dark you can't see your hand afore you,—why, you're sure to begin braying directly we get to the chapel. 'There's old Jack,' father will say. Ah, and if you only knew how glad I've been to hear your voice, Jack, after being out all day with father, and a long trudge home across the mountains—with the rain blowing in your face all the way, may-be, till it made you smart again—yes, Jack, when I've heard you begin braying *then*, I've thought you the nicest and fondest old creature in all the world. I knew I was close at home as soon as I caught sound of *you;* and ain't that beautiful, old boy, when you're so tired you're ready to drop? Oh, you're a good, dear old thing, and it's a wicked shame for any one to hurt you, it is. No wonder you won't let John Jarman ride you, when he's so cruel to you. I don't think, if he was to beat you to death, you'd stir a step with *him*, Jack. No, you'll do nothing but roll in the dust with him on your back, will you, old fellow? Ah! you've got a precious spirit of your own, you have, you rascal! Catch *you* being made to do anything you don't think right! But come, Jack," cried the boy, suddenly starting to his feet, "they'll have done breakfast afore we get home. Look, here's the dandelion wide open, I declare, and it must be six o'clock, at least, by that; for father says it's always time for a labouring man to be at his work when the leaves of the dandelion are un-

folded, just the same as when there's any of the yellow goat's-beard near where he's at work, he always knows, by the closing of the flowers, when it's time to leave off and go to dinner."

Owen and his pet brute jogged along towards the village, the boy with his arm still resting on Jack's neck, and talking to him kindly and fondly as he went—now playfully speaking of his tricks—and then promising him a large slice of bread-and-treacle for his breakfast when they got to the cottage.

But scarcely were they half-way down the common, when Owen could see (as they turned the angle of the road), by the crowd of children and villagers clustered outside his father's cottage, that the work of raising the roof was about to begin.

The sight immediately revived all the lad's thoughts and wonderings of the previous night; and he hurried on, half forgetful, for the moment, of the cruelty of the young blacksmith, or the sufferings of the animal by his side.

Owen was too full of excitement to sit down quietly to the breakfast that had been put aside for him; so, having given the greater part of his bread to old Jack, he darted out with the remainder in his hand, and munched it as he stood in the crowd, looking up, with wondering eyes, at the roof his father was preparing to lift.

The cottage of Davy Evans had very little that was peculiar or picturesque about it, excepting that

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it was much longer than it was high. Built close against the road that sloped down towards the little bridge in the middle of the street which constituted the village, its walls were considerably higher at one end than at the other. At each extremity was a door (as if the building had originally formed two dwellings); the one giving into the kitchen, and the other opening immediately into the parlour; to enter the former, you had to descend some few steps, and the latter, to ascend the same number. Like the generality of Welsh cottages, the walls were so intensely white that the sun shining upon them glistened as it does upon snow, making the little diamond-shaped panes of the latticed window look even of a darker green, and more like bottle-glass, than they were naturally. The roof seemed out of harmony with the walls, which, from their whiteness, appeared almost new; for the thatch was worn and green in parts, with rain, and all but black in others, with velvety patches of moss; while the long line formed by the ridge of the roof at the top bellied downwards as if its back were broken.

Davy had deferred the repairs of this part of the building from month to month, and, indeed, year to year; for it was one of those matters that he thought did not press, and admitted of being put off, day after day, for more important work. But the last March winds had shaken it fearfully; and

when the Wye had overflowed its banks, and laid the whole village under water, and the family had been forced to take refuge among the rafters, Davy had discovered, while imprisoned there, that some of the beams were as soft as rushes with the dry-rot. Ever since that time he had slept in fear of the roof giving way in the first storm, and smothering them all, as they lay in their beds; so he had made up his mind that the next spare day or two he had, he would devote to the repairs of it.

At first he thought the whole of the rafters must come down, but on a more minute examination he found that the beams at the base were alone unsound, so he determined to raise the entire mass above and wedge it up, in order that he might be able to insert some new beams beneath.

As we said, the whole of the little village of Llanvach was gathered outside the cottage, eager to see the wonderful feat performed. There was Evan Griffith of the "public," and Jim Gam, the bow-legged ostler; and there was Toom Price, the preacher of the shop, and all the little Prices, with pretty Lyddy Powell, their servant girl (she had just run out from her work, and had her linsey-wolsey skirt still tucked in a bunch at her back); and Roger Wilkins of the mill was there in his brown paper-cap, with his tall wife in her large white dimity one; and old Betty Watkin, the lame pauper, and Davy

Prichard, the labourer, from the common, with his tools over his shoulder, ready to start on his way to the fields; and Mr. Lloyd, the retired horse-dealer, who lived in the large stone house at the end of the village, with his buxom daughter showing off the new parasol she had lately bought at the market town. On the other side of the road, too, close against the meadow, was old Captain Jones—his long, white hair streaming over his shoulders—seated in his Bath-chair, with the warm sun shining full upon him, and his tidy housekeeper knitting stockings by his side; and looking backward from the bridge stood John Jarman, the blacksmith, with the fish-basket at his back and his long rod dangling over his shoulder like a huge cart-whip, and his boy close behind him carrying the salmon spear and the little keg of beer, slung at his side—both on their way to the ferry to take the "that year's fish" the blacksmith had noted lying under the shelf of rocks, and marked as his prey.

Yes, *all* the little village was there, for Llanvach numbered among its population none but the families we have mentioned. Neither butcher nor baker was to be found in the place; and even "Shoon, of the Falls," who did the little tailoring the villagers required, lived some five miles away, and eked out his living partly by keeping hives and brewing "mead" from the honey (he was celebrated for it half the country round), and partly by acting as

"cunning man" to the simple folk of the neighbourhood, and guessing at the thief when any of their little property happened to be missing.

In front of the rustic group might be seen Davy Evans busy rolling a round clump of wood before the walls of the cottage, and seated on the long stout beam that lay on the pathway was little Owen himself, with his head stretched back and his eyes fixed on the roof, wondering what the clump his father was rolling had to do with the lifting of the thatch. And so rapt was the boy in his own musings that Davy had to call to him some two or three times, whenever he wanted him to fetch any tool from the shed.

But Owen had not long to remain in suspense, for the clump having been placed some short distance from the walls, the beam was soon "canted" on to the top of it so that one end was much longer than the other, projecting far into the roadway.

Then the boy beheld his father mount the ladder placed against the cottage, while his elder brother, assisted by two or three of the stoutest villagers, hoisted up against the wall an upright spar, the upper end of which was placed underneath the eaves, while the lower was made to rest on the shorter arm of the beam.

Yet even now, though Owen saw the beam poised upon the clump, with the short end of it thrust underneath the spar that reached to the edge of the

roof, and the long end protruding half across the road, he could not, for the life of him, understand how all these beams and spars could enable his father to accomplish the object he had in view. To him they seemed rather to increase the weight to be raised than lighten it.

But now came the exciting moment! The little crowd, with Owen amongst the number, were driven back lest either of the beams should fail or the walls give way and injure any of the group. Owen however, all impatience, wriggled himself into the foremost rank, and when he saw the ladder removed he scarcely breathed, so great was his anxiety.

Presently his father advanced towards the extreme end of the beam, and leaning across it, raised his feet from the ground, so that the whole force of his weight might be brought to bear upon it.

"Does it move?" he cried.

All eyes were strained towards the roof, but none could see the least motion in it.

Owen could have burst into tears as he heard the people shout "No!" "No!" and he turned his head towards the bridge to see if young Jarman still stood looking on. But when the lad found the blacksmith had gone, he smiled faintly, for he did not so much care about the disappointment now that Master John was not there to glory in it.

"Hugh! Hugh!" shouted the father, calling to his elder son, and, as the stout lad came running

towards him, he cried, "bear on, bear on! it wants more weight."

Owen as he heard this, half laughed with delight to find there was still a chance of his father succeeding in his object after all.

Hugh no sooner threw his body on the beam, than Owen shrieked—

"It's moving! it's moving!" and as he said so, the boy, half mad with joy, jumped up and clapped his hands, for he had caught a glimpse of a silver thread of light shining beneath the dark eaves.

"I knew I should be the first to see it rise if ever it did so," he inwardly exclaimed, as he swung his arms about, and glanced round exultingly at all the villagers as much as to say, "Look how clever my father is."

"It's going, it's going! Well done, Davy, boy!" cried the neighbours, one and all; and two or three of the most enthusiastic threw their caps in the air.

"Hurrah!" shouted some.

"Hurra-a-ah!" echoed Owen, swelling the cheer, on the chance that young Jarman might still be near enough to catch it; and, as he did so, he turned round once more towards the bridge, hoping that he might have been mistaken before, and that the blacksmith's boy might yet be there to witness the triumph.

"Here, Prichard, good lad," cried Davy Evans, as with his boy he weighed down the long arm of the beam, "run you and slip yon prop under t'other end."

It was but the work of a minute for the sturdy labourer to do as Davy Evans had requested, and the beam once secure in its position, the good man removed his weight from it and hastened to wedge the spar firmly up.

"There," cried Davy, as he drew back and looked exultingly at his handiwork, "I call that a pretty tidy job. It wont take long to get the new rafters under the roof now, and then the old thing will be as sound and strong as when it was first up."

"What do you think of that, lad?" he asked, as he turned to Owen, and patted the delighted boy on the head. "You see it's not so very difficult for a man to lift a roof after all."

"Not for a *man*," replied Owen, looking up at his father as if to measure his height and strength.

"No! nor for a boy either, for the matter of that," replied Davy Evans.

"Could *I* have done it, father," timidly inquired the youth.

"To be sure you could, Owen, if the other end of the beam had only been long enough."

The words sank deep into the little fellow's soul; he could think of nothing else, but that he, a child, could lift a heavy mass like that he had just seen his father raise:

"*I* could have done it!" murmured he, over and over again to himself; "yes, father said so. *I* could

have done what he did—big man as he is—*if the other end of the beam had only been long enough.*"

The thought took such possession of the boy's mind that he no longer saw the things around him, and the crowd of neighbours, who still stood round gossiping, in little groups, about the wonder, was all a mist to him. He neither heard what they said, nor felt them, as some pushed by him to join the others.

"*If the other end of the beam had only been long enough,*" he repeated to himself, as he strolled pensively towards the meadow that led to the water-side.

"Hurrah!" shouted the villagers in one voice, as they gave their last cheer at Davy's handiwork, before going to their labour.

The cry woke the boy from his reverie. As he wandered through the meadow, and could see far away up the river, he caught sight of the square punt crossing the ferry, and he knew by the long fishing-rod carried by one of the passengers, that the blacksmith and his boy were in the boat.

"Young Jarman *must* have heard that, thank goodness!" said Owen, full of glory; and as he strayed along to the water's edge he kept his eyes fixed on the ferry-boat until it reached the opposite shore.

Then dismissing the blacksmith's boy from his

mind and once more recalling his father's words, Owen stretched himself at full length on the bank, and, with his hands clasped on the crown of his head, said over and over again, "*I* could have done it if the other end of the beam had only been long enough. What could father mean? What difference could that have made? *If the other end of the beam had only been long enough!*"

CHAPTER II.

THE BOY-PHILOSOPHER'S FIRST EXPERIMENTS.

How small a spark will fire a train of thought in a young mind!

The boy-poet, Chatterton, could not be made to learn his letters until he happened one day to be struck by the quaint-looking old English characters on one of his mother's thread-papers.

The genius of the illustrious mechanician, Vaucanson, might, perhaps, have been lost to the world had not his father confined him, when a lad, by way of punishment, in a spare room; and the child amused himself by pulling to pieces an old clock that was in it.

And even the great Newton was, as has been before stated, first incited to study by a feeling of revenge that made him resolve to excel a senior boy at school who had severely ill-treated him.

Thus it was with little Owen Evans! Had it not been for the wonder begotten in him by his father's

raising the roof of their cottage, he might, perhaps, have never troubled his brain concerning the laws of motion.

"What difference could it have made if the other arm of the beam *had* been longer?" he asked himself. "How could a yard or two, added to the end of a log, have given me the force of a man and even of a giant? What power has a foot or two of wood to make me lift a weight more than enough to crush me?"

Such were the inquiries that crossed the boy's mind as he lay on his back, with his eyes fixed vacantly on the clouds that flitted across the sky like breath upon a mirror.

Presently he started to his feet, for a sudden thought had struck him.

A short distance from where he lay stood a huge block of stone—a lump of the adjacent rock, torn off by the floods, carried down the stream, and deposited at the edge of the river.

Owen went towards it, and placing his hands against the block, pushed with all his might to see if he could move it.

The effort was vain. The mass was as firm as if it were set deep in the earth.

Then having satisfied himself that he had not power even to shake it, much more to raise it, he turned away, and began hunting among the trees that grew by the water-side.

He did not wander far before he came to the stump of an oak—the one, he remembered, Davy Prichard had felled some days previously—and round about it were strewn a heap of the smaller branches.

Selecting the stoutest and the strongest, he returned with it to the heavy block of stone.

"Now," said the boy to himself, "we shall soon see whether a foot or two of wood will give me power to move a mass like this."

Owen worked the end of the branch far under the lump of rock, and having rolled a heavy stone towards it, rested the branch upon it as he had seen his father do with the beam that morning; then placing his hands at the further end of the branch he bore down upon it with all his weight.

To the intense delight of the youth he beheld the heavy block vibrate to and fro with each exertion of his strength.

"Oh, most wonderful!" he cried, "that a mere bit of wood should give me strength to move a weight a horse could scarcely stir."

"Father said if the arm of the beam were longer it would give more power still." Musing thus, the boy withdrew the branch as far as he possibly could from beneath the rock, and allowed the end merely to rest under the edge of it.

Then once more placing his hands at the further

extremity of the bough, he found that he could stir the heavy mass as easily again.

Owen's mind was filled with astonishment, for now he discovered he could move the solid mass even with one hand; and his delight and wonder rose higher and higher, as he beheld the immense block lean over on its side more and more, in answer to his pressure.

At length the lad grew so excited with the feat, that exerting his whole force, he pressed the end of the bough violently to the ground, and saw, to his terror and amazement, the huge and heavy lump topple over into the stream, making the water fly high into the air as it did so; while the branch, suddenly released from the weight that held it, darted from his hand and whirled upward with a power that to Owen's simple mind seemed something supernatural.

Frightened almost out of his wits, the boy instinctively fled from the spot; and as he darted in and out the trees, his bewildered imagination saw in the shadows of the foliage playing on the ground, a troop of figures hurrying at his heels.

But when he was once more in the broad daylight of the open meadow, his fears soon left him, and as he turned round and discovered that there was nobody behind him, he laughed inwardly as he thought how silly his alarm had been.

At first he felt inclined to return to the waterside and repeat the experiment he had made. Then he stood still for a minute, and asked himself "Where was the good of that?" He had satisfied himself that he had power to move a weight heavy enough to crush him. No! he would go home and see what he could find in the tool-shed that would help him to understand something more about the strange discovery he had made.

As he sauntered across the meadow, he speculated as he went.

"What *can* there be in a mere beam that should render me so much stronger than I am, and why should my force be made greater merely by making one end of a log of wood longer than the other? It's very strange! It's easier to break a long stick than a short one; so I should have thought the longer the end of the beam was made, the weaker it would have been. But it isn't so; or else I could never have moved that stone. I'll find it all out, I'm determined! I wont say a word to father, I'll do it every bit myself, and when I know all about it, I'll make a machine that will lift anything—ay! even a mountain, if I wish it. What will John Jarman say to that, I should like to know? How savage he'll be when he finds I can do more than he can? Yes, I wont rest till I have done it;" and the boy walked quicker as the thought fired him.

"Won't father be pleased, too! Perhaps he'll

think I'm clever enough to go out to work, and then I shall be able to earn some pocket-money for myself, like Hugh does. And young Jarman will find that other boys can do something besides himself. I'm sure I don't see anything so very grand in being able to make the holes in a horse-shoe."

Amusing himself thus by speculating—now upon the delight he was to give his father, and then upon the vexation he would cause the young blacksmith, Owen reached the cottage, and making his way quickly to the tool-shed at the back, he began rummaging among the many odd things stored there, to discover what he could render subservient to his purpose.

First he looked up at the roof, and cast his eyes along the strange medley of old lumber that dangled from the rafters—the donkey's ragged collar, and the battered horn-lanthorn, and the bill-hook. For a moment he thought he would have *that* down, but no! hanging close beside it, he caught sight of the long-handled shears for clipping the hedges, and these, he fancied, would do much better.

Owen was about to mount the little ladder, when it struck him, as he stood on the first step, that he might find something more suitable still. So he went up another step or two, in order that he might take a good survey of the roof, and then he glanced from the spoutless kettles and leaky saucepans—that hung there waiting to be mended—to the hen-

coop his father had made out of the old cradle, and then to the mason's square and plummet—and the old flail—and the many-jointed broom Davy Evans had contrived for sweeping the chimneys—and an infinity of odds and ends besides. But none of them seemed to suit the boy's fancy.

Descending, therefore, from his perch, he began to search in all the corners of the queer building. First he took up the scythe that was stowed away (its blade wrapped round with straw) against the wall. Then he looked at the spades and pick-axes, but not one was to his mind; so he turned towards the rough carpenter's bench, and began playing with the loose handle of the large wooden screw in front of it.

Suddenly a new notion seized him, and he darted over to the discarded pigeon-house that was nailed against the opposite wall, and now did duty as his father's tool-box. From one of the pigeon holes in which the brads and screws were stored, he took a long nail; then returning to the bench, he got the hammer, that lay at one end of it, and drove the nail tight into the wall before him; he had no sooner done this than he proceeded, by means of the same instrument, to draw it out again.

As Owen held the end of the wooden handle, and felt the nail gradually forced from its hold by the iron claw that grasped it, he said to himself, "I could not have pulled that nail out with my fingers.

The handle here, then, gives me the same power as the branch did with the rock."

After this he tried to draw another nail that he found driven into the bench; and now he placed his hand at the other end of the handle, close against the head, but then, strive as he would, he could not stir it; so he slid his hand a few inches higher up the shaft, and then found that, by using all his strength, he could just loosen the nail. Directly, however, he raised his hand to the far end, he could remove it with the greatest ease.

"It's every bit the same as with the beam," he cried; "the longer the handle, the greater the strength it gives me."

Suddenly his eye lighted upon the treadle underneath the lathe, and throwing down the hammer, he hastened towards it. He placed his foot close against the rod that connected the treadle with the axle above it, and pressing on the board, he easily set the wheels in motion. Next, he drew his foot backwards along the treadle, and found that he could scarcely stir it, until at last when he trod right at the end of the board, though he balanced himself on one leg, so as to let the whole of his weight bear upon it, it was impossible for him to give the wheel the least motion.

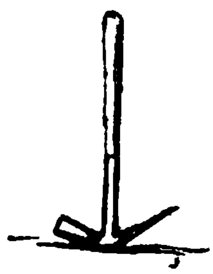
"How strange!" the boy inwardly exclaimed. "I've seen father work at this lathe a hundred times, and I myself have made it spin round over

and over again, and yet I never noticed this before! It's all as father said, I can move anything, if the beam is only long enough."

Owen paused for awhile, and then murmured as he mused again, "Though it's all the same—though the power comes in the same way in every one of these things, yet how different each one is from the other."

Then he got a bit of chalk from one of the pigeon-holes, and began to draw on the bench rude outlines of the several instruments.

"Look!" he cried, still talking to himself, "the hammer is like that—



"And the treadle is like this:—

"And the branch I moved the rock with was so.

"They're not a bit alike," he exclaimed, as he surveyed the rough sketches he had made. "They all turn on different points. See here!" he went

on, "the hammer turns on the head; and the long arm," he said, as he pointed to the line which indicated the handle, "is not in the same direction as the short arm;" and he put his finger on the curved end that stood for the claw of the instrument.

"Now, the branch," he proceeded, "turned on the stone that I set close against the rock, and the short and the long arms were both in the same line.

"But the treadle, again, is different from either, for it turns on the end, and has but one arm instead of two. And yet they're all alike still—for the same thing holds good in every one of them—the longer the beam the greater the strength."

Owen, however, was far from satisfied with the knowledge he had gained. He saw that he was not a whit nearer to the solution of the puzzle—*how comes it that the power depends on the length of beam?*

Seating himself upon the bench, he began thinking what means there were at hand to enable him to clear up the mystery, swinging his legs backwards and forwards as he pondered over the matter.

Suddenly he sprang to the ground, for the pair of scales that dangled against the opposite wall had just caught his eye.

As he snatched them from the hook, he wondered how he could have been there so long without seeing them. They were the very things he wanted

all the while, he knew, and yet for the life of him he couldn't think of them. "He could clear it all up now; yes, he could!—he felt he could!"—and the boy half danced with delight.

Owen was so impatient to come at the result that he would hardly give himself time to suspend the balance from the rafters in the shed. Accordingly, he had to mount the ladder some two or three times before he could get the beam of the scales to hang as he wished. First, the nail was loose; next, the string was too short—then it was all of a tangle.

At length, however, he grew more calm, and in a few minutes the scale beam was properly suspended from the roof. Then he placed in each of the pans an equal weight, and he was delighted to see that the one exactly balanced the other.

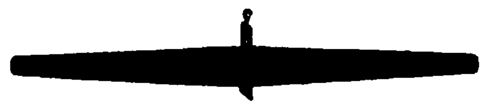
"It is just as it should be!" he exclaimed. "Of course there can be no power gained when the two sides of the beam are of equal lengths, as they seem to be here."

To make sure of the fact, however, he took his father's foot-rule and measured the distance from each extremity to the point on which the beam turned as its centre.

"It is as I thought," he ejaculated, "it's just ten inches on each side."

"Now, then, I'll soon have it!" he chuckled, as he loosened the scales from the strings, and laying

the beam down on the bench, drew, with the aid of the foot-rule, a chalk line straight along it. This he then marked off into inches, so that the beam was scored with chalk somewhat after this fashion—



Having proceeded thus far, he lifted the beam back to its former place, and tied the string round it just at the first mark from the end, so that when suspended from the rafter it hung all on one side, thus—

Owen drew back a few paces to have a good look at the balance, and he stamped his foot on the ground impatiently, as he beheld it all askew, saying to himself the while, "That will never do. I must make it swing straight somehow."

Presently he remembered his father had a bag of shot. Yes, he knew where he had seen it; so he skipped over to the pigeon-house, and thrusting his hand into one of the holes withdrew a small canvas

bag. As he did so a heavy shower of bullets that he had dislodged from one of the corners fell rattling about his feet.

"This is capital," he cried, as he stooped to pick them up; "they're as good again as the ounce weights, and will save me a lot of trouble."

It took some little time for Owen to balance the scales by means of the shot. Having suspended the bag from the upper end of the beam, first it was too heavy—then it was too light—and he had to tie it up and pull it down many times; now taking some out, then putting a little more in, until the impatient lad grew so fidgety over the work that he could hardly stand still to finish it.

At length, however, the balance was fairly poised, and Owen—his fingers tingling with delight at the certainty of the experiment he was about to make—dropped one of the bullets into the scale-pan that dangled from the longer arm.

"Now then," he exclaimed, as he beheld the scale descend, "I shall see how many bullets that one will support."

Accordingly the enraptured boy proceeded to throw first one bullet into the scale-pan, suspended from the upper and shorter end of the beam.

"Ah," he cried, as he rubbed his hands with glee, "one doesn't make the least difference, of course. I knew it would lift that quite easily."

Then he dropped another in—half timidly—for he almost expected to perceive the upper scale-pan sink beneath the increased weight, as he did so.

"No!" he said. "It doesn't fall yet. It lifts twice its weight, that's certain;" and the little fellow jumped again for joy.

Next he drew another bullet from the pocket where he had stored them, and slid it, as gently as possible, down the side of the scale-pan, holding his breath the while, for he made sure the balance would turn this time.

But when he saw it remain steady as ever in the air and that the one bullet supported three others, he clapped his hands again and again, and shouted, "I only wish young Jarman could only see what I've found out."

"Well, another must drive it down anyhow," he said, when his excitement had slightly abated, and he was calm enough to proceed with the experiment. "I don't so much care if it does, either," he added, as he let a fourth bullet fall into the scale.

"I declare it's as still as before," he whispered to himself; "I do really believe it will take another yet. Ay! that it will!" he continued, as he placed his finger on the edge of the pan, to ascertain what power it required to force the beam down. "Yes, and two more, I shouldn't wonder."

Accordingly Owen dropped a fifth bullet in, and finding the beam showed no tendency to descend,

he grew bold now that the first excitement of the trial had passed, and tossed a sixth among the rest.

"Well, I never saw such a thing! I do believe it's bewitched!" he ejaculated, as he flung one more into the scale.

"That makes seven!" he murmured, as he tossed his head in wonder at the fixedness of the beam.

"Well, you shall have another, old fellow, if you want it," he said, laughing and talking to the balance, "I've a lot more in my pocket here."

Still no effect was produced. The one bullet supported the whole eight.

"Yes! and another still, if you like.

"Ay, and another after that."

The beam, however, hung as slanting as ever, with the pan holding the ten bullets poised high in the air, while that with the one in it remained far below.

"Oh! there must be something wrong! The beam has stuck fast, I'm sure," and so saying the boy-experimentalist approached the scales, and once more tried to force down the upper pan.

"No!" he tittered, as he found it yield to his pressure. "There's nothing the matter, it only wants a lot more, that's all," and he rubbed his hands with delight at the seeming incongruity of the matter. "But that difficulty is soon got over," so he threw another bullet into the upper pan.

"There goes eleven, I beg to say!" he remarked.

"Twelve!" he counted, as another dropped from his hand.

"Thirteen!

"Fourteen!

"Fifteen!"

Owen paused once more, for he could hardly credit what he saw. "If father had told me as much, I really don't think I should have believed it," the lad soliloquized. "But there must be an end to it shortly, so I'll put in two this time.

"Now, sir, that makes seventeen you've had!" he went on, still talking to the scales, while he threw in the brace of bullets.

"And two more will be nineteen." Another couple were added to the number.

But scarcely had the second brace fallen from his fingers than the upper pan descended beneath the increased weight.

"I've put in too many," shouted Owen, as he saw the beam go down. "No! I haven't," he cried, when he beheld it rise again, and continue vibrating less and less each time.

"No!—no!——no!" he half whispered, as he watched the space through which it rose and fell become gradually shorter and shorter, until at last, when he saw the two pans equally balanced, Owen danced and capered about, and threw his cap up in the air, half wild with joy.

The excitement over, the boy returned to the scales, and withdrew one bullet from the nineteen.

To his astonishment, he beheld the one in the pan suspended from the long end of the beam lift the whole of the eighteen in the other.

Then he replaced the nineteenth bullet as gently as possible, and finding that it brought the beam back exactly to a balance, he took one of the small shot he had emptied from the bag, and depositing it in the pan with the one bullet, found to his intense glee that the one, with the least weight added to it, would raise the whole of the nineteen others.

"No wonder then," he thought to himself, "that the branch made me move the rock, for that was much longer than the beam is here, and father said the power depended on the length of the arm."

The idea no sooner struck him, than he set to work to ascertain how much longer the one arm of the scale-beam was than the other. Whereupon he proceeded to count the chalk marks on either side of the string by which the balance was suspended.

To his great joy, he discovered that there were nineteen inches chalked on the long arm of the beam, and only one on the short arm.

"Ah! now I see!" he ejaculated, "I see it all; the one arm is nineteen times longer than the other, and therefore it can lift a weight nineteen times heavier than its own. Yes, it's as plain as the 'Garth' yonder. There are nineteen inches on one

side, and only one on the other; and there's one bullet in this pan, and nineteen in that."

He paused for a moment to consider, and then returning to the scales, he said, "I'll soon see whether that's the reason of it, for I'll hang the balance from the second inch here;" and as Owen said the words, he proceeded to tie the string tight round the second chalk mark from the end.

When he had done this he paced up and down the shed, muttering to himself as he went, "Now, there are two chalk marks on the one side, and eighteen on the other. I wonder if I can find out what weight the long end should lift this time. Oh! I have it," he cried, "if I count how many two inches there are contained in the eighteen inches marked on the other end of the beam, that will tell me how many times the one end is longer than the other.

"It's just nine times longer," he ejaculated, chuckling as he made the discovery, "and therefore one bullet, and a little bit, placed in the pan at the long end should be able to lift nine bullets in the other pan.

"Now, I'll see if I'm right!"

Owen was not many minutes in loading the pan at the short end with the requisite nine bullets, and then, with a trembling hand, he dropped the one bullet and the shot into the opposite scale, fixing his eye the while on the beam above.

As the bullet slipped from his fingers, Owen was overjoyed to see the scale descend, and the pan containing the heavier weight gradually rise in the air.

"Yes, I'm right! I'm right!" he shouted, "It *is* as I thought. As much longer as the one end of the beam is than the other, so much the greater weight will it balance.

"I should like to try it once more though. Oh! I never felt so happy in all my life. I would give up anything to be able to find out things like this every day. Ha! and I've done it all myself—that's what pleases me. Won't father be glad. I wonder what he will say when he hears it. He always told us we did not know what we could do till we tried, and I'm sure if I hadn't tried I should never have known what I do now. Yes, I'll try once more, to make sure. I'll tie the string round at the fourth chalk mark from the end now, and see if I can guess how many bullets one bullet will raise then."

Having shifted the string to the stated point, he counted the marks on the long end.

"Now there are sixteen marks on one side, and four on the other," observed the boy. Next he reckoned how many four marks were contained in the sixteen—counting first one four, then two fours, and so on, as he had previously done with the twos; for the little fellow was but slightly skilled in arithmetic.

Having finished the calculation, he remarked that the one was now only four times as long as the other, consequently the least bit more than one bullet in the pan at the long end should lift four bullets at the other.

The point was soon settled, and the boy was once more charmed to find the result turn out as he had conjectured.

"It's all the same, try it any way I will!" he cried. Just as much longer as one arm of the beam is than the other, so much the greater weight will it balance; yes, that's it. I understand it all now."

Then Owen vaulted on to the bench, and sat for a minute or two considering, playing the while vacantly with the stick inserted in the large head of the wooden screw in front of it.

"No! I don't understand it at all—not a bit of it," he suddenly burst out. "How stupid I am," he exclaimed, for—mere boy as he was—he could see, though he could not express it, that he had discovered only the *rule* and not the *reason* of the matter.

"*Why* should one arm of the beam," he went on ruminating, "merely because it's longer than the other, be able to lift a greater weight? *That's* what I want to know. How silly of me to fancy I had found it out all in a minute.

"Dear! dear! I don't see how I am ever to get at

that," he added, after a few moments' consideration. "I wish there was some one I could ask—just to put me in the way, you know. And yet I shouldn't like, either," he continued; "it's so nice after you have found it out, to feel you've done it all yourself, without a bit of assistance from any one. Oh! no, no! I'll try on still! There's nothing like trying, as father says. But how to set about it—that's what puzzles me."

The boy lapsed into another reverie, and at length growing restless at his inability to hit upon any plan that would help him, he jumped down from the bench and began pacing the shed again. But it was all in vain.

Accordingly, after a few turns up and down, he stopped before the scales that were still hanging suspended by the string from the rafters, and loaded with the bullets as he had left them. For want of thought, Owen struck the beam with his finger and made it vibrate up and down.

As the lad stood listlessly watching the oscillations, he suddenly exclaimed, "Look! how much larger a sweep the long arm, as it moves up and down, makes than the short one. The one arm is four times as long as the other," he said, "and as well as I can judge, it seems to go about four times as far. There may be something in that!" mused he.

"I know what I'll do; I'll find out how much farther it really *does* go, and then I'll see whether *that* will help me."

Here arose a fresh difficulty. How was this to be done? there was no means of measuring, with any precision, the space that either arm moved through, in the position that the beam then occupied.

At first Owen thought he would take the balance down, and removing the scale-pans from the ends of the beam lay it on the bench, and there chalk down the lines it described as it moved.

But when he had untied the string it struck him that, even if he did as he had proposed, it would be impossible to make the beam turn on any point but the middle, for there were no holes through it in any other part.

He knew what he would do! He could easily cut out a beam in wood. There were some nice laths handy in the corner.

The notion had no sooner entered his head than the busy lad set to work to carry out his project, and it was not long before he had fashioned for himself a wooden beam of exactly the same dimensions as the iron one from which the scales had depended. Then having chalked the inches all along it, as he had done with the metal-beam, he bored a hole with the brad-awl at the first inch mark from

one end, and after that another hole at the second inch mark, and lastly, one at the fourth.

Next he placed the wooden beam on the bench before him, and driving a small nail through the first hole from the end, proceeded, by means of a piece of chalk held at each extremity, to mark out the lines that both ends of the beam described as it turned upon the nail.

Afterwards he removed the beam to another part of the bench, and having driven the nail this time through the second hole from the end, went through the same operation.

Finally, he repeated the process a second time, but then he took the fourth hole for the centre.

When the work was done, the chalk lines described on the bench were as follows, with the exception of being considerably longer, and they had then none of the "ticks" placed at the side of them.

Owen paused for a moment to contemplate the various lengths of the curved lines.

"It seems to be as I thought," he murmured—"but I'll soon make sure of that."

So saying, the boy took some string, and cutting a piece precisely the length of the smaller curve in the first figure, proceeded to ascertain how many times it was contained in the larger curve, chalking off the lengths as he went.

"That's all right!" he cried, as he summed up the number of chalk marks. The one arm here is just nineteen times as long as the other, and therefore it goes through, as it moves up and down, precisely nineteen times as great a space as the short one does."

Measuring then the second figure in the same rude manner, the delighted boy found a similar proportion between the lengths of the curves and the lengths of the arms; the one end of the beam in this case being nine times as long as the other, and the space described by the long end being consequently nine times as great as the short one.

Nor was it in any way different with the third figure, for here the one curve was four times as long as the other, and the length of each arm in precisely the same proportion.

"Come!" said Owen, as he pondered over the result with no little satisfaction; "I've found out two wonderful things to-day—that *just as much longer as the one arm is than the other, so much the greater weight will it balance, and so much the greater space does it pass through, as it moves up and down.*

"Still," he observed, after a few minutes' thought, "what I want to know is, the reason *why* it does all this. Let me see!" he mused, as he fixed his eyes intently on the figures chalked on the bench. "If the long end passes through a greater space than the short end, and both ends move up and down in the same time, then the one *must* go quicker than the other. Yes, to be sure it must—just as much longer as the one arm is than the other, so much the swifter must its weight travel—that's quite clear."

"But would this make any difference?" he went on. "Can a weight have more power merely because it moves more quickly? It's strange, indeed, if it has."

Then Owen hung the scales up once more, still talking as he did so. But this time he attached the string immediately above the tongue in the middle of the balance. Having done this, he flung a bullet into each pan, and as he made the beam vibrate with his finger, he said—his eyes rivetted upon it the while—"Here the weights are equal, and the spaces gone through, at every turn, by each end of the beam are equal too; so that it is clear one bullet, with the least atom over, in falling through so much space, in such and such a time, will lift another bullet of its own weight just as far, in the same time.

"Now," he continued, "in the case where the one bullet and a little bit lifted nineteen others, the one

travelled nineteen times as far, and nineteen times as fast as the others did; therefore it is plain—since the one bullet lifted every one of the nineteen, just the nineteenth part of its own distance—if we add these nineteen parts together, the whole nineteen bullets must have passed through the same space, in the same time as the one did. There can be no doubt of it," said he, "for look! the long arm fell nineteen inches while the short arm rose one inch; as then *every one* of the nineteen bullets was lifted one inch, it is as clear as can be, the whole of the nineteen together must have gone through nineteen inches, and that in the same time as did the one bullet by itself."

Owen, however, was not yet convinced that he understood the matter thoroughly, and the boy bit his lips with perplexity at the difficulty of the problem.

"But if the *spaces* described are equal," he muttered, still in doubt, "it's impossible to make out that the *weights* are the same, any way."

Then, having considered for awhile, he exclaimed, "No it isn't, either, for as the one bullet falls through nineteen times the greater space, and is always, as it falls, acting on the others, it is evident that it must be one bullet acting nineteen times over. For suppose," he argued to himself, "the ends of the beam had been both of the same length, and the one bullet, and a little bit, had lifted the

nineteen others through an inch space, *one by one instead of all together*. Then, of course, by the time the one bullet had raised the whole of the others one inch each, it would not only have fallen through nineteen separate inches, but, have acted as *nineteen separate bullets*; so that, when one arm of the beam is nineteen times as long as the other, the one bullet does merely the same thing *all at once*, and consequently has nineteen times the power."

The knot once cut in this case, there was no longer any difficulty in comprehending the others. Where the one bullet raised nine, it was now easy to see that the long end of the beam travelled nine times as quick and nine times as far as the short end; and, consequently, that a weight suspended at the longer end had the power to balance nine times as much at the shorter one. While, in the instance where the one end of the balance was four times as long as the other, it was evident, that the long end moved four times as quickly, and therefore had four times the power of the opposite one.

"So then!" ejaculated Owen, "at last I *do* understand it all. It is beyond a doubt that *the power of every weight is greater the quicker it moves*, so that the lightest body, if it could be made to travel fast enough, might have the same power given it as the heaviest—even one of these small shots have the force of a cannon ball, provided the shot travelled as much quicker than the

cannon ball as the ball was heavier than the shot. Oh, yes! it isn't the weight merely that makes the power of a thing. How stupid I've been! No; it's the weight, together with the speed with which it moves. I see the reason now, why I was able to stir that heavy rock. My weight at the end of the beam moved as many times quicker as I was lighter than it—that was the reason. I remember hearing father say once, that some great man he had read about, had declared if he could only get a place to rest a beam upon, he would lift the whole world with a straw. Ay, and so he might, to be sure," added the delighted lad—"with a feather, for the matter of that—if, as father said this morning, the other end of the beam were only long enough."

By this time the brain of the little fellow was wearied almost to exhaustion, so by way of recreation he passed over to the lathe and began working the treadle with his foot, pleased to find how easily now he could increase the power at will. Then he made the wheel spin round violently, and having done so, he retired a few paces to contemplate the rapidity of the motion.

As the wheel slackened its pace, and the spokes became more and more visible, Owen could not help, now that he was somewhat recruited, lapsing into his former train of thought.

"It seems to me," he whispered, "as if those spokes there were only so many levers. I should

just like to find that out, and then I'd have done for to-day. Oh! I see how to do it," he exclaimed; "it wont take me long, now I know so much as I do."

Accordingly Owen proceeded to unhook the treadle-rod from the crank and to remove the strap from the fly-wheel; then he set off into the cottage to fetch the tape measure his father used when tailoring.

Returning quickly with it, he proceeded to take the dimensions round the rim of the wheel, and after that to ascertain the length of the circumference of the axle. Next he measured how many times the one was greater than the other, and finding it to be eight-and-twenty times, he said, "Now, if I'm right, the least bit more than a pound weight at the outside of this wheel should be able to lift as many as eight-and-twenty pounds at the axle; for as the axle," he added, "must turn round once every time the wheel does, a weight fastened to the rim of the wheel would go through eight-and-twenty times as great a space as one hanging from the axle."

It did not take long to put so simple a matter to the proof. Having tied a pound weight to one end of a piece of string, he fastened the other end to the rim of the wheel, and then proceeded to attach to the axle, by means of a stout cord, the quarter of a hundredweight he had borrowed, for the purpose

from Roger Wilkins, the clothier hard by. Next he added a slight extra weight to the pound, so as to give it a sufficient preponderance to start the wheel, and was overjoyed to see the heavy weight rise as the lighter one fell.

"This is beautiful!" he cried, as he repeated the experiment over and over again. "I could tell now what power was wanted to lift any weight if I only knew the size of the wheel and axle, or the length of the two ends of the beam.

The words had no sooner escaped him, than springing up from the ground where he had been kneeling to watch the wheel of the lathe revolve, he shouted: "I know what I'll do! I'll be off to the draw-well,—that's just the thing for me! There's a wheel and axle there, and I'll soon find out now what gain there is in the power with it.

The well to which Owen alluded was at the top of the common. It was not utterly unpicturesque in appearance. Round the mouth of it a stone wall was raised breast high; this was nearly black in the inside, and had a moist green look, while the outside was half hidden by weeds and brambles, excepting where the bright worn handle of the winch projected, and there the ground was bald, as it were, and the grass for some little distance worn and trampled by the many comers. Above the axle was a little roof to protect the cords from the wet,

and the thatch of this was partly covered with thick clumps of bright green moss.

The well itself was noted for miles round for its depth and the purity of the water; though as you craned your neck over the edge of the wall, and peeped down the long dark perpendicular tunnel, the water looked more like ink as it lay shimmering there in the darkness at the bottom.

Owen having come prepared with his tape measure to take the circumference of the axle, was not long in satisfying himself as to its dimensions, and then ascertaining the length of the winch, he described a circle on the ground by means of the same measure tied to a bit of stick, and thus obtained the length of the space passed through by the winch at each revolution it made.

Then, after a long cogitation, he found how many times the circumference of the circle, described by the winch as it revolved, was greater than the circumference of the axle; and so at length discovered exactly how much more easily a man was enabled to raise water by such means than he could without it.

By this time the energies of the little philosopher were fairly spent. He had never thought so much in all his life before, and now that the excitement was over, and he had solved the riddle that puzzled

him, he felt as tired as if he had walked with his father to Builth market and back.

Insensibly the little fellow fell asleep beside the circle he had described on the ground; for what with his restlessness the night before, and the mental labour he had gone through that morning, he was utterly overpowered, and slumbered on without a dream to ruffle his rest.

At length old Jack, who had returned to his quarters on the common, strolled on, as he nibbled the short herbage, to the brow of the hill, and discovering his young master stretched at full length on the ground, began rubbing his nose, as was his wont, against the lad's cheeks.

Owen, roused by the animal, smiled as he opened his eyes, and found his pet brute at his side.

"What, Jacky, are you there? Is it you, you old rascal? You're sure to find me out, you are!" he cried, as he started to his feet, and shook the donkey playfully by his long, furry ear. Then, still full of the discoveries he had made, he said, "Ah, Jack, you little know what I've found out. I wish I could tell you, old fellow, for then you'd be as happy as I am—I know you would. Why, I've found out, Jacky, the way to make you move any weight, and that without tiring you at all, too. I'll tell you what I mean to do, old fellow, when I grow up, and get to have some money of my own. I mean to build a large mill, and make you turn it, Jack; but I shall

have the beam so long, that you will be able to push it round almost without knowing it. Then I shall be rich; and then *sha'n't* you be fat, sir—ah, that you shall! You shall be as fat as Mrs. Williams's lap-dog, over at the Court, yonder. And I'll always have my pockets full of lumps of sugar and apples for you then, old beauty. Ah! who tore my Sunday coat, last Christmas-tide, trying to get at the apples in my pocket, you wicked old thing, you." And the boy hugged the pet brute as he upbraided him.

As Owen jogged down the common talking to the donkey about the many fine things he was to do when he had invented this same grand machine, he caught the sound of the throbbing of the water-mill at the clothier's in the village below, and this started a new train of thought in his mind.

"Many and many a time have I leant over the little bridge yonder," he murmured, as the memories bubbled up in his brain, "and seen the water come pouring down the sluice all of a foam, from the dam beside it, and watched the large black shiny wheel roll round and round, as the troughs filled one after another, while the water dripping from them sparkled in the sun, with a thousand colours—for all the world like the crystal drops to the Squire's chandelier—and the stream beneath was all of a lather, and white as drifting snow. Oh! I think it's the prettiest sight in all the world!" he exclaimed. "I've lain for hours along the coping-stone of the

bridge, and gazed at it all—the little fall with the water streaming over the dam, like a sheet of glass, and the large feathery drooping willow growing from out the high red rock on one side, with the slender branches hanging down, and the tips of them just dipping in the water, and the green reflection of its form showing in the pool below, all zig-zaggy, as the current danced along. Ah, many a time I've sat watching all this, and, as I heard the clatter of the wheels within, mingling with the hum of the falls, I've wondered and wondered how it was that a few buckets-full of water could ever have such power. But now it's as clear as daylight to me. Isn't a bucket-full of water too heavy for me to lift? What, then, must be the power of ten or twelve of these always at work at the edge of a wheel that is as high as our cottage? Why, it must have force enough to do anything. It would tear up oaks as easily as I could pull a rush from a pond.

"I understand it all—I understand it all!" he added; "and now I'll go home, but I wont say a word to anybody about what I've found out till I've written it all down, and then I'll show it to father. I wonder what he'll say when he sees it—whether he'll think me as clever as *he* was at my age? I've heard him say he used to make his own kites and things. If he's very pleased, I'll get him to teach me to turn at the lathe, and then I can make a lot of wheels, and try a number

of things for myself. Oh, yes, I dare say he will, if I ask him, for he's so good to us—yes, very good to us indeed—ever since poor mother died. He isn't like John Jarman's father, always coming home tipsy from the public of a night, and beating his boy about, till his cries sometimes can be heard all over the village. No, father's quite different to that. Why, when he comes home after his work, he sits down to teach us, for he would have given the world, he says, to have had any one to instruct him when he was a youngster. I wonder whether he'll be as glad this time as he was when he found out that I'd learnt myself to read. He said I wasn't old enough, and that there was no use bothering me with such things afore my time—ha! ha! but I used to run round to old Betty Watkin, and get her to teach me my letters out of the sampler, with the funny red worsted trees worked at the bottom of it, that she did when she was a little girl of nine, and 'that's just sixty-two year ago,' the poor old thing used to say. Oh, yes; I wonder if father'll be as pleased now as he was *then?*"

Early the next day Owen was busy preparing for the execution of his plan. Having broken his little earthenware money-box, he took out the new sixpence Squire Williams had given him when he carried home the young Squire's toy poodle dog, after Davy had mended it. With this money, and

a halfpenny added to it, the boy purchased a copy-book and a new pen at the little village shop that was at once the chandler's, mercer's, ironmonger's, stationer's, and, indeed, the repository of almost everything for the neighbouring population.

He then shut himself up in his little room, and proceeded to give an account, in his own boyish way, of the several experiments he had made; these he illustrated with rude sketches of the lever, and the wheel, and axle, showing whence arose the increase of power derived from such mechanical instruments.

It took the lad some days to complete all this, and many an experiment had he to try in order to perfect it. But when it *was* done, it was, perhaps, though Owen himself was unconscious of the fact, the greatest marvel ever wrought by boyish ingenuity.*

Still, delighted as the lad was with the little treatise he had written, he was half afraid to show it to his father, and he put off doing so from day to day, though every morning he made up his mind

* This is no fiction; the boy Ferguson achieved the same wonderful task when he was "about seven or eight years of age;" and the incident of lifting the roof, which has here been made to give rise to Owen's discovery, is merely an elaboration of the event which originally incited Ferguson to the study of mechanics.—See FERGUSON'S AUTOBIOGRAPHY, prefixed to his Lectures.

that he would let him see it that evening after his work was over.

At length, one night, as the timid boy sat twisting the copy book round and round, his father, noticing the fidgetiness of the lad, demanded to know what Owen was fumbling about there.

It was not in Owen's nature to prevaricate, so he told him, "It was merely a little book he had written," and then jumping up and throwing his arms round Davy Evans' neck, the nervous boy hid his head as he kissed his father, and confessed that he wanted him to look over it, but did not like to trouble him.

Davy embraced his boy in return, and Owen, gaining confidence, placed the roll of paper in his father's hand.

"Hem!" exclaimed the good man, half laughing with pride as he glanced over the pages, and minutely examined the penmanship, saying—"Yes, Owey, it's very nicely written indeed for you! The letters are formed well enough, and, if you only take pains, you'll get into a good hand by and bye."

"But—a—a—but it wasn't the writing, father, that I wanted you to look at," stammered the bashful lad; "I—I—I—wanted you to read what it was about."

"Oh," said his father, "I see it's all about levers

and mechanical powers; but I'm tired now, Owey boy; I'll look at it another time. What book did you copy it out of, lad?"

Owen blushed red to the roots of his hair—"I didn't copy it out of any book, father," he answered, nervously, "I did it all out of my own head."

Davy Evans drew himself up in his chair, and looking his boy sternly in the face, said—"Owen, you never told me a falsehood yet."

The little fellow lost all fear in a minute, and angry at his father's doubt, he returned his glance proudly, as he said—"Nor do I tell you a story now, sir!"

The courage, however, that fired the lad lasted but for a moment, and then poor Owen burst into a flood of tears, saying, as he buried his head on Davy's shoulder—"Oh, father, father, you have told me I should not doubt *your* word, then why should you doubt *mine*? You never did so before!" and the little lad sobbed aloud as if his heart would break.

The old man clutched his boy to his bosom, and hugging him fondly, exclaimed—"I was wrong, lad! I was wrong! But come, now, come! wipe your eyes, and tell me what all this is about."

Owen then narrated to him the several experiments, and told his father how those words of his, "if the beam had only been long enough," had so fastened upon his mind, that he could not rest until

he had discovered why a greater length of beam should give greater power.

To the infinite joy of the lad, he beheld his parent, when the tale was ended, open the book, and though tired, as Owen knew him to be, he read every page from beginning to end. As he did so, Owen never took his eyes from the good man's face, but watched every smile and nod of approbation he gave, the boy's blood tingling the while through his veins.

"Very good, Owey! very well done, indeed!" cried Davy, patting him on the head, as he came to the end of the little treatise; "and a wonderful discovery it would have been had no one ever done it before you."

"Done it before!" echoed Owen, as his father's words went through his brain like a pistol shot.

"Yes, lad! if you'll go to Parson Wynn's and ask him to let you see that big book of his, which I used to have reading, you'll find it all printed there, and a great deal more beside."

The words had no sooner been uttered by his father, and Owen learnt that what he imagined he had been the first to discover had already been found out by another, than he dropped into his chair almost broken-spirited with the intelligence.

CHAPTER III.

THE BOY VISITS THE MINISTER.—WHAT COMES OF THROWING STONES.

OWEN was broken spirited.

For a time he sat moodily in his chair, ashamed to cry, and yet ready to burst into tears. All the bright hopes he had raised had been suddenly destroyed. For days he had buoyed himself up by imagining the delight his father would feel on seeing what he had done, and wondering whether his parent would think him as clever as he himself had been when a boy. His chief pride, too, had been that the work was entirely his own, for he could not conceive the possibility of any one having done it before him.

Accordingly when he heard his father say that some one had forestalled him in the discovery, the words came upon him with the force of a heavy blow. All his calculations and contrivances seemed to have been wasted; he had been puzzling his brain for

days to find out that which he might have learned from a book with little or no trouble.

At first he felt so disgusted with the worthlessness of what he had written, that had his father not been present, he would have torn the copybook to atoms. Then what was worse than all, his father seemed to slight his work, and this was almost more than Owen could bear; so he sat silently brooding over his bitter disappointment until Davy Evans, noticing the lad's dejection, inquired what was the matter, saying, "Come, Owey, boy, don't be downhearted."

"I think you're not pleased with me, father," cried the little fellow, starting up and throwing his arms round Davy Evans's neck so that he should not see his tears.

"Yes, I am, Owey," replied Davy, as he patted his boy, encouragingly, on the back.

"No! but you are not so pleased as I fancied you would have been," sobbed Owen; "I thought you would have kissed me as much as you did when you discovered I had taught myself to read, and I am sure what I've done now was much harder to find out by myself than the alphabet was. But all you say at present is, 'that some one has done it before,' and you ask me what book I copied it out of; but what hurt me more than all was, you declared I was telling you a story. Oh, it's very

cruel of you," he cried; the tears gushing from the poor lad's eyes as he summed up his grievances.

The good man smiled as he heard the boy upbraid him for his want of encouragement; and as he clasped him to his bosom, he said, "Well, well, lad, perhaps I haven't been so kind to you as I ought, and didn't praise you for what you had done so much as I should, if I had only thought for a moment, Owen, how soon you take a thing to heart. There, don't fret, boy! I think it very clever, I'm sure; and there are few men that could have done what you have. Now, does *that* please you?"

Owen laughed outright through his sobs, and answered, "Yes, father, it *does* please me—it makes me feel so happy, I can't tell you. I could do anything to hear you talk *so* to me, for then I think I am getting a big man, and shall soon be able to work for myself. Do you think I shall ever be as clever as *you* are, father?" he inquired.

"Yes, Owey," chuckled the labourer, "and a deal cleverer, too. Remember, I had nobody to teach me when I was a youngster, for there wasn't a man nor a woman in the village then as could read. Old Squire Williams's father, to be sure, they used to say, was a great 'scholard,' but he was always out fox hunting, or shooting, or fishing, or something of that kind; and there were no Sunday-schools neither in them days. Besides, I was put out to a mason when I was five year old, and had to be off

with him at six in the morning—sometimes to go ever so many miles to the work, and obligated to run all the way there, too, for my little legs couldn't keep up with his long ones. There was no learning to read in such times as them, Owen; and I was a grown-up man afore I felt the want of it. It wasn't till I married your mother (rest her soul!) that I got to know my letters. She were obligated to be a bit of a scholard, for her father, you know, kept the Bronllys turnpike, and she had to take the tickets sometimes. I wouldn't let her teach me, though; I was proud-spirited, you see, and liked to do everything for myself; so she just put me in the way like, and I wasn't long afore I got hold of the whole of it. When I found the help it was to me, I used to tell her that our children shouldn't be brought up without any learning, if I starved for it."

"It was very good of you, father," said Owen. "Poor mother used to teach Hugh, I remember, and look what a clever scholar he is. Why, he can tell how much timber there is in a tree merely by measuring it."

"And so will you, boy," answered Davy, "if you go on in this way. You'll be able to do much finer things than that if you'll only strive, for there are wonderful matters to be learnt, Owen. I am sure, when I used to read in that big Cyclopædy of Parson Wynn's, the astonishing things that had

been found out, I've thanked God over and over again that I've lived to know so much of his goodness and glory. Often and often I've wished I were a gentleman, with nothing to do but to study such matters and teach them to you, my lad. Some day, Owey, you'll get to read about the stars, and learn how every one of the little tiny specks of light you see in the heavens are great big worlds, and how they are millions and millions of miles away; and you will see, then, how clever men have measured the size of them, and weighed them, and told how far distant they are."

"Oh! father," cried the boy, his mind almost overpowered with wonder, as the flood of new thoughts swept through his brain, "who could ever do that? Why the stars are too far away for any one to get to measure them, as I've seen Hugh do with the trees; and if they are so big as you say, how would they ever be got into a pair of scales to weigh them? I always thought they were like those 'jack-o'-lanthorns' one sees after dark, floating about in the air over the marshes. Oh, I *should* like, father, to learn about the stars."

"All in good time, lad," returned Davy, laying his hand on Owen's head; "you've got more than twenty years the start of me, and besides you are well on the right road now. So go you up to the Parson's to-morrow, and learn all about what you've

been doing—they call it the laws of motion, I think—and directly you know them, you can set to work about the stars as soon as you please."

Early the next morning the little fellow set off delighted on his road to the minister's, and as he went, he called at the mill to return the weight he had borrowed of Roger Wilkins a day or two before.

The water-mill of Llanvach was one of those little old-fashioned factories, studded throughout the country, where the work-people consist merely of the owner's family, and the farmers for miles round bring the produce of the last year's shearing to be made up into cloth for their coats, or linsey-wolsey for their dames' gowns, and where, when the work is slack, the weaver occupies himself by making up a small roll of Welsh flannel to take to market on his own account. On entering the little factory, Owen was half-bewildered by the clatter of the machinery, the whirling of the wheels, and the hurrying to and fro of the long leathern straps that extended from one end of the shed to the other. On one side of the building stood the carding machine with one of the Wilkins boys feeding it with wool, the white flocks clinging to his dark hair and eyebrows like gossamer to the bushes. At the end of the building was the wife in a huge long pinafore, tending the spinning machine; while on the other side was the loom at which Roger Wilkins himself was seated, with the threads like cobweb stretching before him, and the shuttles

darting in and out between them like bats flitting in the dusk among the branches.

Roger Wilkins knew sufficient of mechanics to be able to direct the repairs of his own mill; so when Owen showed him the little book he had written, with all its ingenious experiments concerning levers, and wheels, and axles, the clothier, pleased with the boy's tastes and the cleverness he had displayed, "knocked off" working for awhile, and took Owen round the mill to explain to him the uses of its several parts. He showed him how one cogged wheel with fifty teeth to it working into another that had only ten teeth, caused the second to make five revolutions in the same time as the first made one, and how the power of the second was, consequently, five times less, for, said he, "every machine is merely an instrument for changing the direction of a force, or for increasing either its power or velocity."

"You see here," said the weaver, "in this mill, the direction of the force of the water is entirely changed. The stream, you know, Owen, is running on in a straight line outside, and here we have the force twisting round and round in this carding machine, and moving up and down in that loom."

Then Roger Wilkins reminded Owen that a windmill was a machine that changed the direct course of the wind into a circular one, causing the stones to revolve, and so to grind the corn.

"Indeed, this change of the direction of a force,"

he added, "is one of the main objects of every machine, but," continued he, "another object is to increase either the power of the force that drives the machine, or else its rate of travelling."

When the power is increased, Roger told the boy it was always done at the expense of time, saying, "Just as much stronger as the machine makes the force, so much the slower does it travel."

"And when the rate of travelling is increased," he added, "it is always done at the expense of the original force; for just as much quicker as the machine moves than the force, so much the weaker is its power."

"Look, Owen!" he went on, "these wheels here travel many times quicker than the water-wheel; that is, while the water-wheel goes round once, they go round some hundred times, and therefore the force in them is more than a hundred times less than it is in the large wheel outside."

"It is precisely the same in a clock," he added. "See, lad!" the weaver said, as he drew Owen towards the large wooden timepiece that hung against the wall, "this is the weight that sets the whole in motion. Just feel the heft of it!"

The little fellow placed his palm beneath the mass of lead, and found it was almost more than he could sustain with one hand.

"Now," proceeded the weaver, "mount them steps, and touch the top wheel, and then see how easily you can stop the whole. Do you observe, my

little man, you can prevent this heavy weight falling with the mere force of your finger?"

Owen descended the ladder, delighted with the experiment he had made; the more pleased to find that everything he saw and heard confirmed the truth of his own discovery.

"Look you, boy!" continued Roger Wilkins, "that wheel you touched is the one that moves the pendulum of the clock, and goes round once in about half a minute, while the minute-hand, which is driven by the weight here, goes round once only in an hour; consequently it travels something like one hundred times as quick as the minute-hand, and so takes a hundred times less force than would be needed at the axis of the minute-hand to prevent the weight falling."

After this, Roger showed the lad how easy it was (upon the same principle) to stop the mill, though the water-wheel itself, he said, had power to crush either of them.

"But there are many machines just the reverse of these," the weaver went on to say, "and where the power is increased by the rate of travelling being decreased; such are cranes, where a man is made to lift as great a weight as twenty or even a hundred men could raise without any such instrument; but in all such cases the machine causes the weight to travel as many times slower than the power as the power is rendered greater by it. The wheel and axle at the well is only another instance of the same

kind; so that you see, Owen," he added, "there are but two things a machine can do—the first is to change the direction of a force, and the second either to increase its power by decreasing its speed, or to increase its speed by decreasing its power. Or to put the matter more clearly, we may say it is impossible to augment both the power and speed of a force at one and the same time; for just as many times as the one is made greater, must the other be lessened."

When the weaver had finished his little lecture on mechanics, he patted the boy kindly on his shoulder, and bade him come in to see them whenever he wanted, assuring the little fellow he would always be glad to help him in any way he could. Roger only wished that his lads were half as handy as Owen was.

Owen blushed again, and thanked Roger Wilkins kindly for all he had told and shown him, saying, "I can't tell you, Mr. Wilkins, what a deal I've learnt from you;" and then adding, that "he was going up to Parson Wynn's, to read there in the big book his father had learnt out of," the boy put on his cap, and was about to depart.

"Here! Owen, Owen!" shouted the weaver, as he sat down again to his loom; "I've got something for you. I didn't think of it till it caught my eye here."

Owen Evans hastened back to the weaver, and found him in the act of taking down some dusty looking curiosity from the top of the loom.

"Look here, lad, this'll just do for you," said Roger Wilkins, as he puffed a cloud of dust from the crannies of the wood-work, and disclosed a little model of a water-mill. "It's an over-shot wheel, just like the one here, and all done to scale, too. It's many years ago since I made it. I was up at Llanelly then. There, take it with you, lad, it'll be a nice toy for such a boy as you. My lads would only break it in a week; they've no taste for such things."

"Oh! thank you, sir," cried Owen; "thank you;" and the enraptured boy turned the model round and round again, as he greedily eyed every part of it. "Did you cut it out with a knife, sir?"

"Ay, I'll tell you all about it when you come in another time," answered the weaver, impatient to get to his work again. "And I'll tell you, my boy, nice stories about Arkwright, the poor penny barber, who invented one of our best spinning machines, and made no end of money by it—died the richest man in the kingdom. I'll tell you, too, how his wife in a passion broke the model of the machine when he had finished it, vowing it would bring them to ruin, and that he'd much better keep to his penny shaving. Ha! ha! ha!" roared the weaver, tickled at the recollection.

"No, *did* she though!" exclaimed the simple-minded boy; "it was very cruel of her."

"Yes, lad, it was. There, there, you go now, I

haven't time to talk, for I must finish this 'cut' afore nightfall," responded the weaver. "When you come again, I'll have thought of a lot of stories for you, about people that have invented things. There's poor William Lee—that's very pretty—the scholard of Cambridge, who invented the stocking-frame—a wonderful thing that!—he did it from watching the motion of his wife's fingers whilst she was knitting a pair of stockings, as she rocked the cradle with her baby in it, when they were very poor. But there! there! you must go, Owen, or I shall stop chattering to you all day and get no work done."

Clank, clank, went the loom again, and the little factory rattled once more with the motions of its many wheels.

"Mind you come again soon, Owen," roared the weaver, through the noise. "Such nice stories!"

Owen nodded, as he smiled at the weaver, and then lifting the latch, took his departure with the little model under his arm.

As the door slammed back, the weaver stopped his loom for a moment, and shouted to his wife, "That little lad will live to be somebody, take my word for it, girl."

Little Owen, having left the model at home, went jogging merrily on his way to Parson Wynn's, thinking over the while how kind Roger Wilkins

had been to him, and how much he should like to hear the stories the weaver had promised to tell him about the great men who had invented the wonderful machinery for spinning and weaving. Then the lad fell into a reverie concerning the poor penny barber, and wondered how one so poor could ever have learnt enough to become so clever. This kindled in the boy a hope that, poor as he was, still, by striving, he one day might find out something which would bring his father "a goodish bit of money," and that would be very nice, for then the old man needn't work any more, and he (Owen) would no longer be a burden to him.

When the little fellow had exhausted this part of the subject, and had mentally made everybody in the village happy and comfortable with his imaginary riches, he amused himself by contemplating the immense amount of knowledge he fancied himself the possessor of. He repeated, over and over again, to himself what the weaver had told him was the twofold object of all machines, saying, as he sauntered on, and strove to impress the fact on his memory, "Every machine has only two uses; the first use is, to alter the direction of a force, and the second—let me see! what was the second? I remember the first well enough, for Mr. Wilkins said the force of the water outside his mill was in a straight line, and inside it was made to turn round and round, and so to card the wool and spin the threads. But how

stupid of me to forget the second use. Oh! I know it now!" he said, as the memory flashed across his mind; "the second use was either to increase the power by decreasing the speed of the original force, or else to increase the speed of the force by decreasing its power. Yes, that's it!" exclaimed the excited boy, striking the palms of his hands together as he went; "I know it all! and I'm sure I could tell now what was the gain or loss of power in any machine I saw. I should only have to calculate how many times quicker or slower the machine went at the end where the work was done, than it did at the beginning, where the force was set to drive the wheels, to find out exactly how much stronger or weaker it had become. Oh! isn't it beautiful to know all this. Whenever I see a windmill or a watermill again, I shall understand all about it, and I shall be able to tell any one how the force of the wind or the water is made to move round and round inside the mill, instead of going on in a straight line as it does outside of it."

All this, Owen, as we have said, repeated to himself again and again, so that he might be perfect in the matter by the time he got to Parson Wynn's, for the boy was anxious to let the minister see how much he knew on the subject, and then, perhaps, Mr. Wynn would let him have the big book by and by to read by himself.

Thus occupied on the way, Owen at length reached the residence of Parson Wynn. It was

a moderate sized cottage, built sideways to the road, and all that could be seen on approaching it was its white gable end, for the front was half hidden by the trees of the small orchard that grew in the meadow before it. The only point at all remarkable in the exterior, was the two huge flat stones placed slanting over the door-way, so as to form a rude kind of porch.

Within the door (that stood always open) might be seen the bright white tins and yellow brass candlesticks shining over the mantelpiece, while ranged beside the ample fire-place appeared the minister's large hooded bee-hive chair, with a brown ham or two dangling from the rafters above it; and stowed away in the far corner the eye caught sight of the large cask of cyder—the produce of the last year's crop of apples from the little orchard without.

The room thus seen served not only for the kitchen and sitting-room of the minister and his daughters, but it also formed the work-room of the two girls, who were the milliners and dressmakers to the surrounding villages; and generally the little table by the window was littered with some bright-coloured cotton print that "the Misses Wynn" were busy making up, according to the last Brecon fashions, for one of the neighbouring farmers' wives.

The minister himself was far more peculiar than the cottage in which he lived. Had it not been

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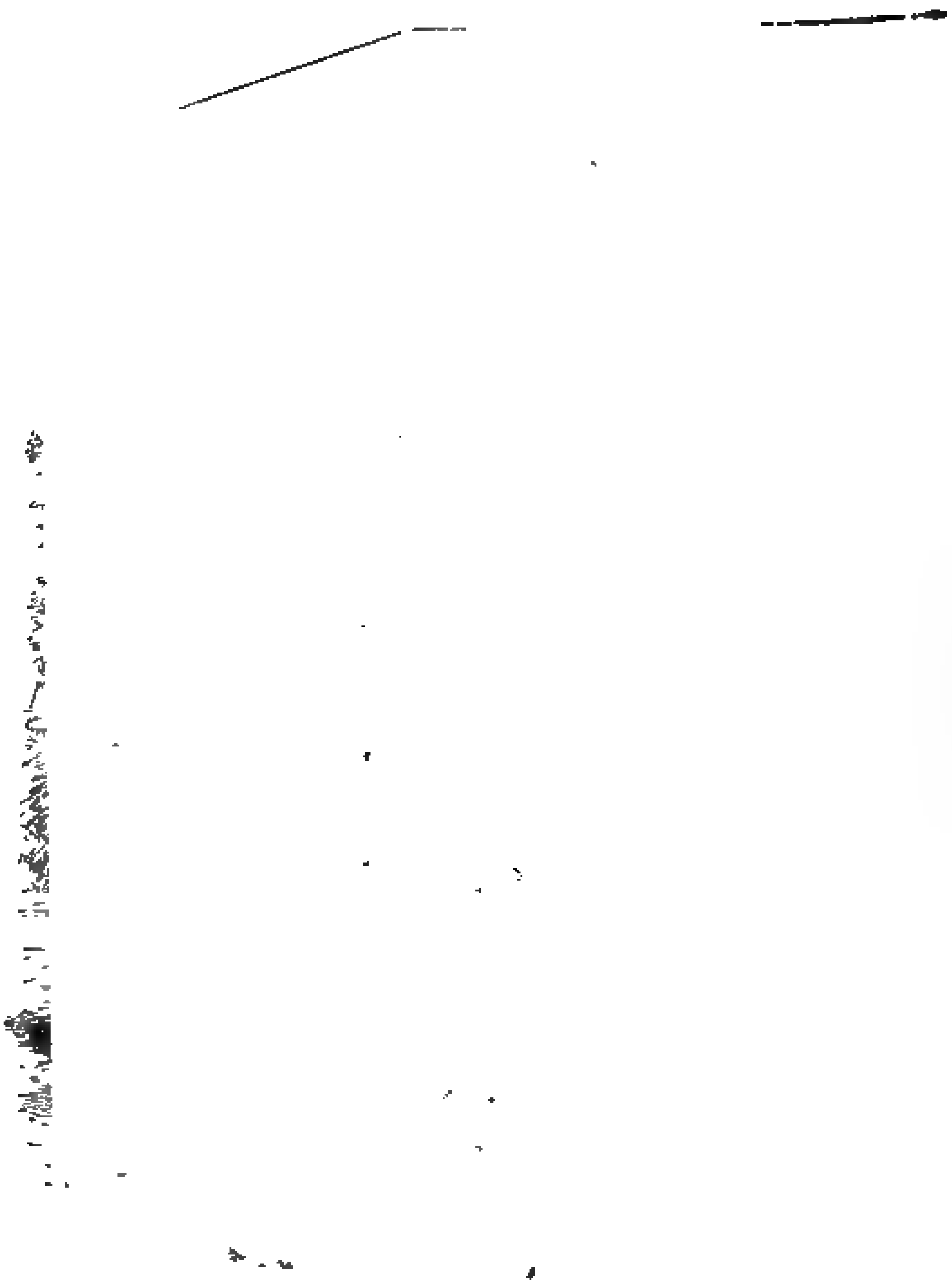
chin and cheeks, even when newly shaven, wei
blue as the bloom on a ripe plum; and the



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for his white cravat (tied like a whisp of muslin round his neck) and his long Quaker-cut black great coat, it would have been difficult to have distinguished him from a farmer; for he wore a felt hat, somewhat of the shape of a wagoner's, but of a rusty black hue, and the nether half of his body was incased in what the people round about *would* call "*a* drab breeches," and high Wellington boots that reached up to his knees.

This costume the clergyman had adopted on account of his having to ride some fourteen miles to his little mountain church—or rather chapel, for it was no bigger than a cowhouse, and had nothing but a bell perched at one end of the roof to mark it as a place of public devotion. Every Sabbath he and old Jessie, the mare that nibbled the grass among the apple-trees in the orchard during the week, might be seen jogging along with one of the girls perched up a-pillion behind, and the other walking by the side, on their way to early morning service—the minister, and his family, and horse, being entertained at some of the farmhouses on the hills between the hours of worship.

It did not require a second glance at the Parson's face to tell that he came of the ancient British stock, for his complexion was of the swarthiest hue, his eyebrows thick and black, while his chin and cheeks, even when newly shaven, were as blue as the bloom on a ripe plum; and the hair,

which hung long and lank about his shoulders, was as black as the fringe round his pulpit. His figure was tall and spare, and rendered more ungainly by a roundness of the shoulders that amounted almost to a hump.

The girls were sufficiently like their father to be far from prepossessing in appearance, for they were disfigured by the same rotundity of shoulder, while their arms were unnaturally long, and their hands almost ape-like in their dimensions.

At first, it was far from pleasant to look upon them, and yet as you got to know them, and to become better acquainted with the kindliness of their natures, all recollection of the original impression wore off, and you grew to think them almost pretty. The devotion of the girls to their father was a beauty not to be forgotten. Their mother they had never known—for they were twins, and she had died a few hours after they were born.

Nor were the virtues of the girls confined solely to their own home, for they were the nurses to the sick poor for miles round, and scarcely a cottage could you enter but some villager had long tales to tell of their goodness and charity. Without the means to render any pecuniary assistance in the time of distress, they brought to the suffering what it was impossible for money to purchase, and what even the poorest have it in their power to render,—sympathy and consolation. Then, too, they were the

peacemakers of many a home, and boys who dreaded their father's anger always flew to them.

The girls had long ago made up their minds (as they said) "never to marry," observing, playfully, that they were too ugly for any one to think of having *them*, and doubtless it was a sense of their personal defects that made them cling the more fondly to their father; for when the old man, who from long association and deep affection for his children, had grown to be almost blind to their deformity, used to twit the girls with leaving him some day for some good-looking fellow of a husband, they would assure him that nothing on earth could ever make them part from him. Nor was this a mere passing sentiment, for so conscious were they that it was their destiny never to be linked to another, that they had been led to seek a livelihood for themselves, well knowing that their father's humble means (the "living" of the little parish yielded him but twenty pounds a year) were insufficient for the maintenance of them all.

Owen, indeed, loved the two girls dearly; he scarcely knew which he liked the more. Betty was so kind and gentle, and Lucy so playful with him. He could just remember the many weeks they had sat by his sick mother's bedside night after night—first one and then the other—all the time she lay ill with the fever; and how they used to bring her nice cooling drinks, and would come and read to

her when she was able to bear it. Then, after his poor mother's death, when his father hardly knew what he was to do with little Peggie, the girls had taken her home, and brought her up like one of themselves.

There was no house that Owen visited with greater delight than Parson Wynn's, and none at which he was more welcome. He had long ago got to call the girls "Auntie," although they were in no way kin to him, and he never went to their cottage but one of them was sure to fill his pockets with apples for himself and old Jack, and the other to give him one of the dough cakes, hot from the oven, whenever she had any baking going on.

The girls no sooner heard the gate creak on its hinges, as Owen let it swing back, than Lucy put down her work to see who was coming; and as she caught sight of the boy tripping along the pathway, she ran towards him with her arms outstretched, and throwing them about him, as she stooped down, kissed the little fellow again and again.

Then she seized the boy by the hand, and dragged him along as she ran back to the door, crying to her sister, "Auntie Betty! Auntie Betty! here's little Cock Robin come to see us."

"Auntie Betty" no sooner heard the words than she left the lump of dough she was busy kneading (for it was her week to do the duties of the house), and hastened to meet the boy.

"Don't touch me, Robin, dear," she said, thrusting back her bare arms, which were as white as a plaster-cast with flour, and craning her neck forward, as she pouted out her lips to kiss the lad, "don't touch me, or I shall make you like a little miller's boy."

As soon as the congratulations and embracings were ended, Lucy commenced, as usual, putting Owen "to rights," as she called it.

"Dear, dear Owen, what makes you drag your hair into your eyes in this way?" she cried, as she took off his cap and lifted his head back by his chin so as to have a good look at him; "you seem to take a delight in hiding your nice forehead," and so saying she drew one of the side combs from her hair, and began to make the lad look (to use her own words) "like a little man."

"There!" she cried, kissing his forehead, when she had combed the hair from it, "you're something like my clever little Robin now, but before, I declare if you didn't look like that sleepy old Jack of yours—indeed, indeed you did, sir."

This operation was no sooner finished than "Aunt Betty," who had been intently watching the effect produced, exclaimed, "*Do* look, now, at the boy's collar. Whatever has he been doing with the corner of it?"

"Oh! you little monkey, you've been biting it! It's all wet, I declare! *Uch-a-vee!*" screamed Lucy,

as she let it fall from her fingers, and added, playfully, "Was a poor little Robby so hungry then that he must nibble his shirt collar along the road?" Then suddenly altering her tone, she inquired sharply, but half laughing the while, "what *ever* made you do it, sir?"

"I don't know, Auntie," replied Owen, as he looked astonished at the moist and mangled corner; "I wasn't aware I had done it. You see I was thinking of a lot of things as I came along, and I suppose I got biting it then."

"You're always thinking, little Mr. Clever, you are," returned Lucy, patting him playfully on the cheek. "I'm sure if I didn't know you, I should fancy you were not 'all there' sometimes," she added. Suddenly she cried, "Oh! look here! just see what a state now your boots are in! Why the upper leathers are as wet as that nasty sucker of yours. There, go and take them off, or you'll be catching your death of cold, and then we shall have to nurse you. Go and take them off, sir, *do*, and pop your feet into my side-laced boots while they are drying by the fire."

The latter part of this speech was spoken so sharply that, though Lucy meant it for fun, Owen, who knew he had been too much occupied on the road to pay attention to the swampy places that lay in his way, and was half ashamed to find he was nearly wet through to the feet, took it

seriously to heart; and fancying the girl was really scolding him, he could not refrain from sobbing as he knelt down on the hearth rug to unlace his soppy boots.

Betty caught the sound of the lad fetching his breath through his tears. Hastily rubbing the paste and flour from her arms, she ran to him, ejaculating, "Why, Lucy! you've made the poor child cry," and then lifting him on to her knee, she hugged him fondly to her.

The tender-hearted Lucy no sooner heard the words than she flew towards her sister, and kneeling down at her feet, said, as she placed her cheek near Owen's; "Why, Owey, boy, I was only in play! Auntie Lucy wouldn't hurt her dear little Cock Robin," and then she began prattling to him as women love to do to pet children. "There! him dry him little eyes." (Betty wiped them with the corner of her apron.) "Oh! he's his Auntie Lucy's own dear little Cock Robin, he is, and a ducks-a-diamonds, too," babbled on the girl, while she pressed his cheeks between the palms of her hands.

Owen burst out laughing amidst his tears, and kissed both the girls, as he said, "I can't bear to think you are angry with me."

"There, never mind!" exclaimed Lucy, running into the adjoining room, and returning with a wet towel and hair-brush. "Let me just wipe your face with this now, and put your hair straight a

bit, and then my little Cock Robin will look like himself again."

As Lucy was busily engaged in rubbing the boy's cheeks until they were as red and shiny as the apples in the orchard, Betty was soothing him the while by promising to make him a nice sweet cake directly she had got the dough in the oven.

In a few minutes the two girls had resumed their work. Betty was burying her knuckles in the dough, which yielded like an air cushion to her pressure, and Owen on a stool at Lucy's feet, holding up the skein of white silk that she was winding on one of "THE MISSES WYNN'S" cards.

"Who are you making that grand cap up for, Auntie Lucy," inquired Owen, as he moved his straightened hands to and fro to let the silk wind off them.

"It's Lyddy Powell's, of the shop," answered Lucy. "It's for her wedding, Owey, and here's the gown she's going to be married in. "Don't you think it's sweetly pretty? Her master made her a present of it—it's one of the most expensive cotton prints he had in his shop. Isn't it a nice genteel pattern? We were both of us up all last night finishing it."

"When you are going to be married, Owen, will you let us make *your* wife's wedding dress?" asked Betty, looking round, as she placed the large red earthen pan of dough before the fire to rise.

"Yes, that I will," innocently responded Owen, "because it will be for *yourself*."

"Oh, indeed, you little fickle fellow!" cried Lucy, laughing. "Why you told me the other day that you meant to have *me*. I shall be nice and jealous."

"Well then, Auntie Lucy," responded Owen, "I'll never marry at all, for I love you both alike."

"He's a darling!" exclaimed Betty, as she turned back to the table; "and now I'm going to make him the nice seed-cake I promised him, and he shall have it hot out of the oven when he goes home this evening."

"Yes," answered Lucy, "and then he can take Betty Watkin's loaf down to the village for us, so as to let her have it new for her supper. Besides, it will save the poor old cripple the walk."

"To be sure," added Betty, "and Owen can carry her at the same time the bottle of stuff I've made up for her to rub her leg with, for the old woman says it gets to pain her dreadful now she grows in years."

"Ah, but little Cock Robin must promise us to take great care of it, and not to get thinking again on the way," laughed Lucy. "Oh, Betty, Betty," then she cried, as she glanced out of the window towards the orchard, "just come here and look at father yonder."

The sister left the cake she was preparing, and

ran to the casement, Owen at the same time starting to his feet.

"Well, what *will* father do next with that mare!" exclaimed the girl, as she stretched her neck over Lucy's shoulder. "Why, I do declare he's giving the creature a drink of table-beer out of our pudding basin!"

"And just watch the old thing!" interposed the sister. "*Isn't* she pleased? See how she's whisking her long tail about. I think she dearly loves a drop, do you know, Betty?"

"Ain't they like two kittens at play, Owey?" asked Betty, as she pointed to her father and the mare in the orchard.

"Yes," replied the boy, "and isn't he a kind old man to be so good to the animal? He's had her ever since she was a colt, hasn't he, Auntie?"

"Ay, that he has, and now the poor old creature has got scarcely a tooth in her head, and is nearly as blind as a bat in the daylight," returned the girl.

"Oh, yes," repeated Owen, "Mr. Wynn is very kind—*very*. I remember he told me a long time ago it was by kindness all animals were tamed, and that they were only savage because they were afraid we intended to hurt them, and they were obliged, for their own protection, to be always on their guard. But directly we taught them, by being continually kind to them, we didn't mean to

harm them, and that they were quite safe with us, and were fed by us instead of being ill-treated, they all became as gentle as cats, which, I recollect, he said were the most savage animals—kinds of tigers, I think—in a wild state.

"There's a good tender-hearted little fellow," cried both the girls, as they kissed him one after the other. "Very nicely said too, Owen."

"Yes, Owen," said Betty, "there's no power like kindness in all the world. We may force both men and beasts to do what we want through fear, but then they are always ready to deceive us. By treating them kindly, however, we make friends of them, and then they are anxious to serve us of their own free will, even before we desire it."

Encouraged by the precepts of the gentle girl, Owen told her he had brought something to show Mr. Wynn—something he had been writing "out of his own head."

"*You've* been writing something out of your own head!" echoed the astonished Betty. "Let me see it, *do*." Whereupon the two sisters pressed round the boy in their eagerness to discover the subject of his work.

Owen drew the copy-book from his pocket, and having handed it to them, the girls held it between them, and ran their eyes over it hastily together.

"I don't understand a bit about it," said Lucy,

"but I dare say father will. I'll run and call him to you."

"*Isn't* he clever?" whispered Betty in her sister's ears, as they both stood at the door.

"Father! father!" shrieked Lucy, running in pursuit of her parent, and dodging under the boughs of the trees, as she went, "here's little Owen Evans come to see you."

In a few minutes the girl came tripping back to the kitchen, crying, "Owen! father says you are to go to him. You'll find him down by the cherry-tree. You're to take with you what you want him to read, and a couple of chairs as well."

When the boy had left, Lucy returned to her seat at the window to finish the wedding cap, and as she fashioned the white satin bows, she cast her eyes occasionally to the end of the orchard, where she could just see the old man and the little boy, their figures dusked by the shadow of the tree under which they were sitting.

"There's father kissing little Cock Robin, Betty! and now he's rubbing his old spectacles with that bit of wash leather he always carries in his pocket. I can tell what he's doing as well as if I was leaning over his shoulder. I *do* wish he would wear something besides that old straw hat, Betty, when he's at home. I can't bear to see him in it."

"Yes," said the sister, "when we get paid for Lyddy Powell's things, we'll buy him a nice black

velvet skull-cap next time we go to Brecon. I've seen them marked up very cheap at 'LONDON HOUSE,' in the High-street there."

"Now father's patting Owen on the head, Betty," continued Lucy, as she stopped sewing and gave a fresh glance towards the couple. "He's very pleased with the little fellow's work, I know, for that was always his way with us."

"I *do* think he's as proud of that boy as if he was one of his own," the sister exclaimed.

"And now he's taken him up on his knee," added Lucy, looking side-ways, like a bird, towards the orchard again, "and he's put his arm round his neck."

"Ah! he wont be able to bear Owen's weight long," remarked Betty, "for father isn't half as strong as he was a year or two back."

Then came a short pause.

Presently Lucy cried, as she glanced from her work once more towards the end of the orchard, "I wonder what's the matter now! Here comes Master Owen, tearing and skipping over the grass like our Jessie used when she was a young foal. He's as pleased as Punch, I can see!"

In another moment the boy bounded into the room, his cheeks flushed crimson with excitement, saying, "If you please, Auntie Lucy, Mr. Wynn says will you give me one of the volumes of the Rees' a—a—I forget the other name——"

"Cyclopædia," interposed Lucy.

"Yes, that's it! out of the sitting-room," added Owen. "It's the volume containing the letter M he wants, please Auntie."

As Lucy stepped into the adjoining room to fetch the book, Betty ran towards the boy and inquired, "What did father say to your work, Owen?"

"Oh, he said it was a wonderful thing for me to do all by myself," answered the delighted boy. "And what do you think, Auntie? he told me I was just like father—he did indeed, indeed. And now he's going to read, and explain to me all about mechanics out of the big book that father got his learning from. Isn't it good of him?"

"There, take care of it," said Lucy, as she returned with the heavy volume and placed it in the boy's arms. "Mind you don't fall down with it as you go, or else father would never forgive you; for it was given to him by his godmother when he took his degree at Lampeter College, and she was own cousin to the gentleman who wrote it. Mustn't *he* have been a clever man, Owey, to do all that?"

The boy was too impatient to stay to answer Lucy, and had no sooner got the huge book under his arm than back he scampered, eager to compare the discoveries he had made, as to the power of the lever, with what was printed in the book his father had studied from.

At length the volume was spread open in the

Parson's lap, and the lad was kneeling by his side, looking over the page as the old man read aloud, explaining the difficult passages and "hard words" as he went. And when Owen found that he was right in all the facts he had set down, the little fellow's heart throbbed audibly, and looking up in the minister's face, he said, as his eyes almost filled with tears, "Oh, *isn't* it a pleasure to find we're right, Mr. Wynn?"

"It is, my lad," the parson replied, "when we delight in the right merely for the right's sake, and not because it makes us proud of our own petty powers. I hope *that* is not the cause of the pleasure you say you feel, Owen."

"Oh no, sir; the reason why I am so happy," returned the little fellow, "is because, far from being proud, I was doubtful of my own powers, and what I have done serves to give me some little trust in myself. But why is it wrong, Mr. Wynn, to be proud?" inquired Owen.

"Because, my boy," answered the minister, "it makes us despise all those whom we, in our stupid conceit, fancy to be inferior to ourselves. Then, again, pride is invariably the result of ignorance. The proud man has his eyes always turned to the earth, and seeing only those things that are beneath him, gets to fancy himself something vastly superior to the worms at his feet; whereas the humble man looks upward ever, and with his eyes fixed upon

perfection, feels how small and insignificant a creature he must be in the eyes of the Omniscient. A man, proud of his little knowledge, Owen, is like the owl who begins to see in the dusk, and mistakes the darkness for the daylight; but the man humiliated by his learning is like the same bird in the sunshine —the excess of light serving only to make Nature appear still dimmer to him."

Then the Parson proceeded to read to the boy about levers, and wheels, and axles, and pulleys, and inclined planes, and wedges, and screws, explaining to him, by familiar illustrations, the law which regulated the increase of power in each of them. And when he had brought the little lecture to a conclusion, he pointed out to Owen that there was but one rule governing the whole, namely, that the gain of power was always in proportion to the loss of speed; and that for a lighter force to lift a heavier, it was necessary, in all cases, that the heavier should rise just as many times slower as its weight was greater than the lighter one, adding, that a machine—no matter whether it consisted of levers, wheels, pulleys, inclined planes, wedges, or screws—was chiefly an instrument for attaining such an end.

"Oh, yes, I understand it all thoroughly, thank you, sir," said Owen, when the clergyman had finished. "I never thought about the inclined plane before, but now I see that it's only another

means of doing the same thing as the lever does in another way—that is of making a lighter weight fall quicker than a heavier one rises, and so enabling the less to lift the greater one. Oh, yes, I see it all clearly now, Mr. Wynn, and I shall never forget it, I am sure," and in his excitement Owen rose and began half dancing, while he added, triumphantly, "I know all about mechanics *now*."

"Nay, nay," said the minister, smiling at the self satisfaction of the boy; "not quite so quick, my little man. If I'm not much mistaken, you know very little about the matter."

Owen looked confusedly at his tutor.

"You know, lad, only about the dead inert instruments that are used to modify the forces that put them in motion," answered the clergyman, reproving the little ebullition of boyish pride; "but of the forces themselves, sir, what do you know? and with them is the high knowledge, after all, Owen. The machines, boy, are of the earth, earthly; but the forces that quicken them come from the Great Fountain of all power, and turn the mind to Heaven, filling it with higher and nobler thoughts."

The clergyman was delighted as he watched the eyes of the boy wander in his amazement to and fro. He could see he had opened a new vein of thought in the youth's mind, and it was one that the minister felt far more pleasure in working, than that with which they had been previously engaged. To say

the truth, Mr. Wynn had but little love of science in his soul, and he delighted to travel from the physical to the metaphysical, that is to say, from the ordinary operations of nature to the subtle and mysterious principles which are concerned in producing them. It was this quality of his character that had made him instil into Owen's father a sense of the superiority of the principle of faith to that of reason as a guide to knowledge; for he was fearful, lest the untutored mind, whilst contemplating the mechanism of the universe, should, in the rapture of its first perception of the beauty and order of creation, ignore the powers of the Great Artist who designed and perfected the whole. Science to Parson Wynn was but the translation of the physical Bible, the deciphering of the will of the Almighty as written in the heavens, the air, the earth, the waters, and the creatures that live and breathe therein. And he cared far less for the physical happiness that a knowledge of the laws governing the elements was the means of rendering humanity, than he did for the spiritual elevation it had the power of producing. In a word, he loved the poetry of science as much as he despised, and indeed dreaded, the literality of it.

"The *forces!*" echoed the bewildered Owen; "I never thought of them."

"And yet," returned the minister, smiling, "you say you know *all* about machines now. Like the

short-sighted owl I told you about, Owen, you mistake the dusk for the daylight. Every machine requires some force to drive it. When once set in motion, the instrument is governed by regular laws, modifying either its power, its speed, or its natural course; but the great question is,—what is the nature of the wondrous principle that primarily moves it?"

Mr. Wynn looked at Owen, and paused again for awhile to watch the workings of the lad's brain through his eyes.

Owen said not a word.

"The great forces of the world, my little man," continued the minister, "to which humanity is indebted for all that is produced, and every change that is wrought without and within us, are as numerous as they are various.

"First there is the wind which turns the mills that grind our corn, and drives the ships that bring us the luxuries and comforts of other lands; and which here fans us with its breezes, and there devastates cities, or lays a forest like a field of corn, with its hurricanes.

"Secondly, there is the power of the water, at one time refreshing the earth with the bubbling up of its springs, and at another deluging it with the outpouring of its torrents; and this power again is used not only to grind our corn, and to work the machines by which our clothes are spun and woven

—the timber sawn wherewith to build our houses—and many a like service rendered us; but also to give an irresistible hydraulic pressure even to the energy of a child, and to carry our vessels, by means of the locks to our canals, up some steep declivity.

"Then comes fire—the force to which we owe some of our greatest benefits and some of our greatest evils. It is this which expands the water into the steam that drives the many engines in our towns now-a-days. It is this that impels our carriages across the land with the rapidity of a whirlwind, and our vessels across the seas despite of adverse winds. It is this force again, which, acting on gunpowder, breaks up huge rocks into workable stones, and gives a deadly speed to the bullets and balls which nations use in warfare to destroy one another. And it is this same force which, diffused in the sunbeams from above, quickens the benumbed vegetation, pushing forth the buds, expanding the flowers, and ripening the fruit and grain on which we live; and which, imprisoned in the bowels of the earth, bursts forth in burning fountains from volcanoes, and floods the soil around with red-hot streams of liquid lava.

"Next comes gravitation, drawing down the weights of our clocks, and forcing up our balloons, and keeping every thing fixed in its place to the earth, and above all, producing not only the tides, but

the wonderful revolutions of the planets and the stars, even to the remotest corners of the heavens.

"And after that, we have the wondrous and subtle power of electricity, as seen in the lightning; this, man has already trained to carry his messages with the speed of the light over the land and under the water, as well as to work the metals for him, to move his time-pieces, and to guide him by means of the little magnet's unerring finger across the pathless seas.

"Then follows the force of elasticity, which men in olden times availed themselves of to drive the arrows from their bows, but which serves us now for kindlier purposes, making the strings of our musical instruments vibrate, and giving power to the springs of the little watches we carry about us. It is to this force too that we owe the rebound and play of the various gases and vapours in the atmosphere around us.

"There is also the force of cohesion, from which every material that we use either in our buildings or our machines derives its strength; as well the force of crystallization, binding together the parts of some rocks, separating and so breaking up others, and (as in the crystallizing, or 'freezing' as it is termed, of water) rending pipes, splitting trees, and crumbling the soil.

"And again, there is the force of what is called chemical affinity—which is the power that produces every change, and every fresh combination among

the elements round about us; making the fire burn, rusting the metals, dissolving the rocks, feeding the plants, and even sustaining the life that is within us.

"And lastly, we have the force of animal life itself—the most wondrous of all—without which it would be impossible for us to make a single movement, and to which we owe not only the benefits we derive from our own exertions, but all those man reaps from the many beasts of burden he has trained to serve him—the ox that treads out the corn; the mule that carries the mountain pack; the deer that draws the snow-sledge; the camel that bears the traveller across the desert; the horse that moves our carts and carriages."

"Dear, dear!" said Owen, when the long catalogue was ended. "I shan't be able to remember it half. What a deal there is to be learnt. I shall never know as much as *you* do, Mr. Wynn. I thought when you had read to me about mechanics I understood all about powers and forces, and now I see I understand little or nothing about the matter."

"Ay, my boy," responded the minister, "the more we know the more there seems for us to know. The circle of knowledge is very much like the horizon, Owen. The ignorant man thinks there is nothing beyond what he sees; but the wise one knows that, travel towards the limits of that

circle as far as he will, he will never get to the end of it."

"But do tell me, Mr. Wynn," interrupted the eager boy, "what *is* a force?"

"That is more than I can do, lad," replied the clergyman. "All I can tell you is, that it is not matter. By that I mean it is not solid, nor heavy, nor has it length, breadth, or thickness, like the ground and stones at one's feet; and yet some force is the cause of solidity, heaviness, extension, and every other property of matter besides. You cannot have a pint of a force, Owen, nor yet a yard of one, nor yet a pound. The principles that give power to the elements in the world without are something as subtle and mysterious as that which quickens and strengthens you yourself. All the wisest of us can do is to give this same force a name, and call it 'spirit,' so as to distinguish it from the 'stocks and stones' which would remain for ever immovable without it."

"Force is spirit, then," mused Owen.

"Look you!" continued the minister, as he rose from his seat and picked up a stone from the ground. "Here is a dull dead lump of matter; place it where you will, there it must remain to all time, unless stirred by some force, for it has no power to move itself. Now, see Owen! I jerk my arm suddenly, and away the dull dead stone flies through the air like a bird, instinct with a determi-

nation to proceed in the course in which I pro pelled it."

"How strange!" cried Owen, as he watched the missile dart over the trees. "I've thrown many a stone, and yet never thought why it moved before."

"What did the stone get from me, lad?" inquired Mr. Wynn. "Say that I injected into it some subtle fluid or 'ether,' as it is termed, but this will not help you, for the subtlest fluid is but a light gas after all, and gas is only solid matter in the form of vapour, and therefore dead and inactive as the stone itself. So you see, Owen, the only thing the stone could have got from me was force, and force, as I told you, is spirit."

"Was your spirit in the stone, then?" asked Owen.

"Part of it most assuredly was," replied the minister. "Did not I determine it should go in the direction I flung it, and was it not quickened with the same determination immediately it left my hand?"

"That it was," said the perplexed lad.

"A force, then, Owen, would appear to be simply a determination—or inclination, if you please"—remarked the clergyman, "given to a body to act in a particular manner. Consult what force you will, it merely amounts to this. Now determination or inclination are the terms we give to the operations of our will, so that we must conclude that force is the

result of will. But matter, being dead and inactive, can have no will of its own; hence, whatever force resides in it must have arisen from the will of *some one else* having been impressed upon it, precisely in the same manner, lad, as you saw my will just now impressed upon that stone."

"I begin to see," said Owen, thoughtfully. "The wind has a force because it has had some *will* given to it. But *whose* will, sir?"

"The will, my little man," said the minister, in a kindly voice, "of that Great Being who willed the light and the light came."

"Oh! sir," exclaimed Owen, "you have filled my mind with thoughts that almost overpower me. So all the many wonderful forces you spoke of just now are merely the workings of God's will?"

"You are right, my good boy," murmured the minister, as he let his hand fall on Owen's shoulder. "God not only created the world by His will, but it is His will that upholds and sustains it to this day—prolonging Creation as it were by the continuance of the very power that called it into action. The Almighty, you see, Owen, did not create the world and then leave it to follow out the laws He had impressed upon it, but His will is still active everywhere, and to be perceived in everything; in the lightning and in the sunshine—in the streamlet, the dewdrop, and the ocean—the summer breeze and devastating whirlwind—in the sprouting seed, the

opening flower, and the leafless forest—the falling stone and the revolving planets—in the change of the seasons, the succession from day and night, and the transition from life to death—all are the results of the will of Him, the Great Fountain of every force without and within us."

Owen was lost in contemplation for awhile. Presently he exclaimed, "I shall now see God in everything." And as he threw his arms about the good man's neck, he added, "Oh, you've made me *so* happy, Mr. Wynn. I've never felt like this before. I can't tell you what I mean. I don't know the words to use, like you, sir, but I feel my thoughts lifted far away till it seems almost as if I was up amongst the stars. I shall never forget what you've told me to-day—*never*." Then the boy let his head fall on the minister's shoulder, as if entranced with his meditations.

"You can now see, I dare say, Owen," returned the clergyman, "that the law of the lever and the inclined plane is but the Almighty's will expressed in those instruments."

"Yes, of course it is," murmured the boy, as he raised his head and withdrew himself abstractedly from the minister. "Will you let me go home now, Mr. Wynn. I'll come again to see you soon, but at present, I'm so confused, I hardly know what I say. I should like to go home and be quiet."

Parson Wynn was too pleased with the evidence

of the impression his precepts had made upon the boy to seek to interfere with his desires, so telling him he should like to see him again soon, and to hear how he progressed with his studies, he accompanied Owen to the cottage, and told his girls that the little fellow was going home.

"Oh, dear!" they both cried, "I thought we should have had him to tea."

"Whatever *have* you been doing with him, father?" said Betty, drawing Owen to her side, and kissing him again and again; "he looks quite an altered boy."

"Yes," chimed in Lucy, "and little Cock Robin was so merry when he left us."

The girls soon perceived by their father's look that he did not wish them to press their inquiries; so packing old Betty Watkin's loaf and Owen's own seed-cake in a little basket, they took an affectionate leave of the lad, and watched him saunter homewards along the lane, with his eyes bent upon the ground.

"What *is* the matter with the child, father?" Betty and Lucy inquired, as they returned to the kitchen.

"The little fellow, my girls, has learnt," replied the minister, "to find 'sermons in stones, and GOD in everything.'"

CHAPTER IV.

THE BOY TRIES TO MAKE A CLOCK, AND HAS A TALK WITH THE MASTER OF THE MILL ABOUT CLOCK-WORK.

As Owen journeyed back from the parsonage, he knew as little of the way he went as when he came. He was busy all the while revolving in his mind the subtle lesson he had been taught by the minister.

The boy had learnt, for the first time, that there were other things in the world besides what he could see and feel, and that these constituted the most wonderful and mysterious part of creation.

"The force which moves me," he mused, while remembering what the clergyman had told him, "as I walk along now, is spirit, and without this spirit my body would be like that stone. Yes, it *must* be so! I remember poor mother as she lay in her coffin, the last time I ever looked upon her. When I touched her hand it was as cold as the stone itself, and, oh, so heavy!—as I took it up it fell from mine like a dead weight would have done. How different to when she was alive! When I touched her hand

then, it pressed mine and curled about my neck, and hugged me to her with a force that made my heart leap again. Yet when she was dead, poor thing! there she lay, the same in body but without the same spirit to move her. *That* was the only difference between her dead and her living, and yet how great a difference it was to me. Nothing I could see or feel had gone, and yet all had fled that made that form *my mother*. How strange I could not think of this then."

The trees that arched above the lane rustled with the passing breeze, and turned the lad's thoughts into another channel. As he saw the shadows of the leaves that mottled the ground dancing among the sun-drops at his feet, he stood still, and looking upwards said: "What is it makes those branches swing in the air, but the Great Spirit, who, as Mr. Wynn said, is the Fountain of all Power?"

When he had reached the end of the shady lane, and looked down into the valley beneath, the boy, intent on discovering everywhere some instance of the principle which absorbed his whole thoughts, paused for awhile to note the forces that gave life to the scene before him. First he tracked the little brook winding through the thick dark wood that, like a mass of nodding plumes, overhung the dingle; he beheld the distant streamlet, narrow as a silver riband, twisting and turning as it traversed the thicket, now lost among the foliage, now beaming

in the sunshine, like a plate of mother-of-pearl, iridescent with its many colours, and now white as a snow-drift as it tumbled headlong over the brown rocks.

Then he glanced at the fields of ripe corn undulating in the breeze, like a sea of gold, and watched the reapers in some, their figures half hidden among the ears, and the tall stalks falling around them as they went; while in others that were tufted over with many a sheaf, he saw the high-piled wagon, with its long team, go tottering through the gate, the yellow load swaying to and fro on its way.

Next, he marked the sails of the towering windmill flashing in the sun, and their long black shadows flitting, as the wings revolved, across the hill-side meadow that sloped before it.

After this he noted the white round masses of clouds above him—heaped up and dazzling as if they were mounds of snow sparkling in the sunshine—go drifting across the blue lake of the heavens, and shading the fields below for a moment, as they swept over them, like a passing memory. And he beheld the thin grey smoke rising straight up from the cottage beside the dingle, and filming the foliage like a veil of the thinnest gauze before the trees.

The little lark, too, he saw bound from the corn-fields high into the air, carolling joyously

as it fluttered up and up, and the white-bellied swallows skimming and circling over the surface of the river, with the cattle drinking at the pool, their legs half hidden by the stream, and the reflection of their brown and white forms tinting the water beneath them.

Then, as the breeze blew towards him, he could just catch the ring of the blacksmith's hammer on the anvil, the throbbing of the clothier's water-wheel, mingled with the shouts of the village children, and now and then the tinkling of some mountain sheep-bell.

As Owen observed all these signs of motion and life, he could not help thinking of the many various *forces* that he now knew were necessary to animate the busy scene. And he wondered how he could have lived so long, seeing only those things that were palpable to his senses, and failing to perceive the mighty and mysterious power without which all things must have remained as dull and motionless as the rocks about him.

This truth once impressed upon his mind, the boy could think of nothing else all that day and a good part of the night too, for in the change from light to darkness he traced the same Almighty power at work. As he watched the moon rise in the heavens he lay awake thinking of the Great Spirit that moved it; and when he beheld the stars come peeping out, one after another, through the blue

vault above, he speculated, in his own simple way, upon the Omnipotence of Him whose Will moves and governs all things.

Next day, however, when Owen rose, boy-like, his mind was filled with a new thought. He was determined to put his mechanical knowledge to some practical test, and it struck him that the best thing for him to make would be a clock.

It would be so nice to have a time-piece in his own room, the little fellow thought; for then he would be certain when it was five in the morning, without listening for Jack at the kitchen door; for the knowing brute was the chief guide as to the hour he had now. It was true in summer Owen knew the time by the place of the long shadow from the spruce-tree that skirted the meadow facing their cottage. But then he had noticed that the shadow did not fall across the same part of the road as the days shortened and lengthened, and it cost him no little trouble to make due allowance for the difference; while in the winter he was in the habit of telling when the hour arrived for him to get up by the setting of one of the bright stars behind the western edge of the Garth on the other side of the river; but this again he could do only when the weather was clear and frosty.

Accordingly, it did not take him long to determine that it would be much better to have a clock

of his own making; for it would be so pleasant, he fancied, to watch the rod that hung at the back of it swing to and fro, and hear it "tick" and "tick" till it lulled him to sleep in the bright summer evenings.

Owen was busy the whole of that day planning the machinery for carrying out his project. He was anxious to contrive it all himself. When Roger Wilkins had told him to put his finger on the top wheel of the Dutch clock in the factory, the boy had just had time to notice the arrangement of the works, and he wanted to see whether he knew enough about mechanics now to be able to make a timepiece like the clothier's; so, though he felt tempted again and again to run round to the mill and ask Mr. Wilkins to let him have another peep at the wheels, his desire to accomplish the task without the least assistance was too strong to allow him to do so. Indeed, Owen was naturally of too inventive a turn of mind to sink without a struggle into a mere copyist.

"The short hand," he said to himself, as he bit the end of the pencil he had procured in order to sketch down the plan, "goes round once every twelve hours, and the long hand once every hour; so the one hand revolves twelve times as quick as the other." *That* he could easily manage. He'd make a big wheel with a heavy weight to pull it round, and it should have twelve times as many teeth round it as a small one had, and then of course

the small wheel would turn twelve times as fast as the big one did.

This at first appeared to Owen to be all that was required. But presently he began to ask himself how he was to prevent the weight descending at too great a rate, for upon this he soon saw the whole depended. "If the weight falls too quickly," he said, "the hour hand will move too fast, and then the minute hand will do the same, of course. I see," the lad cried, "everything rests upon the rate with which the weight descends. And how am I ever to make a weight fall as regularly as the clock should go."

For awhile Owen remained silent, brooding over the problem.

In a few minutes, however, it struck him that if he was to double the weight, it would fall as quick again, and that if he halved the weight, it would fall only half as quick. So he thought all he had to do was to adjust the weight to the rate at which the wheels were to turn.

Still, after some further reflection, the boy was far from satisfied that the increasing or decreasing of the weight, according as the hands moved too slow or too fast, would have the desired effect.

"A leaf," argued Owen, "doesn't fall to the ground at the same rate as a stone, certainly. But then," he added, "the leaf does not fall straight down; for it seems to be blown about by the air,

and so it must take a longer time to reach the earth. Now, suppose I was to take a small stone and a big stone," the boy went on reasoning to himself, "would the big one fall quicker than the small one? I should fancy it would, because a heavier weight must have more power than a lighter one. But there's no use fancying," he said, rising from his seat, and throwing the pencil down on the table, "the best way is to try whether it will or no."

Accordingly, Owen hurried off to the well; for that seemed to him the best place for performing the experiment. There having provided himself with a large stone and a small pebble, he was astonished to find, on letting them fall, both together, from his hand, that the two struck the water at one and the same time.

This was a new source of wonder to the little fellow's inquiring mind, and to convince himself of the fact he repeated the experiment again and again, each time varying it in some slight form.

At first he searched about for eleven pebbles that were each, as near as he could judge, of the same weight. Then having tied ten of them together in a piece of paper, he let the packet of pebbles and the single one fall at the same moment, and found precisely the same result produced—the time occupied in the descent of both being equal.

Then he went in quest of eleven more pebbles,

each alike in weight, and let them drop, all together, loosely from his hand. Still there was no difference in the effect; as he craned his neck over the edge of the well, he could perceive every one of them dimple the water at the same moment.

"I see how it is now," he said to himself, as he turned from the well and proceeded homewards. "The big stone that I let drop at first was about ten times as heavy as the little one, and so was like ten little stones made into one, just the same as when I tied the ten pebbles in a packet together. Now there's nothing very strange in the fact that one stone of the same weight as another should take the same time to fall through the same distance. Then if two stones do this, why ten or twenty, or a hundred stones, of the same weight, would do so too; and it's no matter whether the stones be separate, or all made into one big and one little one, for it can only be the same number of stones after all. It wouldn't have made any difference either, I can tell, if I had used pound weights instead of stones, for a weight of a hundred pounds can only be made up of a hundred different pounds; and as each of those pounds, if they were all separate, would fall to the ground at the same time as another pound, why of course they must do the same when they are made up all together into one heavy weight.

"So then," murmured Owen, "here's another wonderful thing I've found out. A feather must

fall to the earth at the same rate as a hundredweight, for if the hundredweight was a hundredweight of feathers, of course every one of the feathers in the hundredweight would fall at the same time as each by itself would. It's only because light bodies float in the air that they take longer to go through it than heavy ones. If we could only take away the air, why then the lightest would reach the ground at the same time as the heaviest, I'm sure of that now."

"Isn't it wonderful!" he cried, walking quicker and quicker, as he grew more and more delighted with the strangeness of the discovery. "I never would have believed it if I hadn't tried it, and I'm sure I should never have dreamt of trying it if it hadn't been for making the clock."

The idea of the clock had no sooner crossed his mind again, than his thoughts reverted into their former channel.

"Now," mused the lad, "if great weights fall at the same rate as small ones, how would it be possible for me to make the wheels of the clock move round as regularly as the hours go on."

Then, as he turned his steps towards the dingle, instinctively seeking out some sequestered spot where he might quietly ponder over the problem, he busied himself, as he sauntered along, with devising a variety of projects by which he fancied the desired end might be attained.

It struck the boy that, as the air retarded the descent of bodies, it might be possible to make the weight of the clock fall at the proper rate by means of a wheel with fans to it, that should press against the air as the wheels revolved. Still the boy saw no means of regulating such an apparatus easily; so he fancied it would be better and simpler to put a drag upon the wheel, as he had seen the wagoner do to prevent the wagon descending the hill too rapidly. After a few moments' reflection, however, he thought there would be the same difficulty with this as with the other. It would cost him no end of trouble to adjust the motion by such means.

Suddenly Owen remembered that at the back of Roger Wilkins' clock there was a rod with a round weight at the bottom of it, that kept swinging to and fro as the clock ticked. He stood still as he asked himself what could be the use of that, and wondered whether it was intended to make the wheels move at a proper rate.

"It must be so," he said; "but how can *that* do it?"

The little fellow puzzled himself with his endeavours to understand the use of the pendulum until he was fairly worn out. It was beyond his simple powers to comprehend; so, at length, when he had grown fidgetty with his inability to account for its action, he determined upon going to the mill and asking Roger Wilkins to explain it to him.

As Owen journeyed towards the little factory, he was delighted to find that the mill had ceased work-

ing, and he remembered then that he had heard his father say there wasn't enough water in the stream to drive the big wheel. This gave the little fellow courage, and he quickened his pace, anxious to avail himself of the clothier's leisure.

The lad found Roger Wilkins alone, enjoying his pipe at the factory door, his wife having availed herself of the holiday to go over to Brecon "shopping," and taken the boys with her. Owen had no sooner explained the cause of his visit than the clothier, delighted to foster a talent in any way connected with machinery, led the lad inside the little building, and taking down the clock proceeded to explain to him the use of its several parts.

"So you want to know about the pendulum, Owen, do you?" inquired Roger; "and you thought you could make a clock without one, eh? That *would* have been clever, lad! for shall I tell you what a clock is? Why, do you know, a clock is only a piece of machinery for marking the number of swings made by a pendulum—or rod as you call it—and for forcing the pendulum at the same time to keep on swinging. This heavy weight here, you see, makes the clock go; that is to say, it makes the pendulum continue to move backwards and forwards; but it's the pendulum itself, my lad, that keeps the time. Look at this," he continued; "I'll take the pendulum off. Do you hear, Owen, at what a rate it's running? 'Tick! tick! tick! tick!' it goes. Why it's more like calling pigs than beating seconds!"

The boy laughed at the clothier's illustration, and asked—"Does the pendulum, then, beat only once every second, Mr. Wilkins?"

"Yes, my lad," answered Roger; "and now, of course, little Mr. Inquisitive, you want to know why it does that? Well, I've a little story to tell you on that point. I know you like stories about inventions and discoveries, and so do I, Owen. I remember many of the wonderful things that have been found out merely by the stories about them.

"Well!" proceeded Roger Wilkins, as he filled a fresh pipe, and seated himself on the edge of the carding machine, "you must know that nearly three hundred years ago there was a young Italian student, named Galileo Galilei. He lived to be a great philosopher afterwards. It was he who put together the first telescope—that's a kind of spy-glass for looking at the stars, and making them seem ever so much nearer—and it was with this he discovered that one of the stars, called Jupiter, has got four moons to it, Owen—four moons! just think of that, and we've only one."

"Dear, dear!" exclaimed the enraptured boy.

"Well, when he was a youngster of nineteen," babbled on the clothier, "and had just returned from college—where his father couldn't keep him any longer, because he was too poor—young Galileo happened one day to enter the cathedral of Pisa—that was the town in Italy where he lived, and indeed,

where he was born. Then walking down the middle of the church, he noticed one of the lamps swinging—it was suspended by a long cord from the high roof—and it struck him, as the motion grew less and less, that, no matter whether the distance the lamp went was great or small, it swung backwards and forwards in the same period. So what did he do but set to work to time its swinging by his own pulse, and he found that it took just as many pulsations to go a short distance as it did to travel a great way. Afterwards, when he had become a great man, he applied the knowledge he had gained in this way to the regulation of clocks, by means of a pendulum.

"So you see, Owen," added the clothier, "the swings, or vibrations, as they are called, of the pendulum, are all performed in equal times; that is to say, a pendulum takes no longer to swing a moderate distance than it does a short one. Now it has been found, lad, that a pendulum a little bit more than $3\frac{1}{4}$ feet long, will swing once exactly every second, or 60 times a minute; and that if the pendulum be 13 feet long, it will swing once every 2 seconds, or but 30 times in the minute, whereas if it be only about $9\frac{3}{4}$ inches long—inches, mind!—it will do so once every half second, or as many as 120 times every minute."

"How very strange!" cried Owen, who had sat all the while with his eyes rivetted on the clothier. "I never could have found *that* out. Mustn't master Gali—what's his name?—have been clever, Mr. Wil-

kins? But what's the reason, if you please, sir, why the pendulum swings so regularly?"

"Ah, that's more than I can tell you, boy," answered Roger. "It's beyond me, for it wants a good deal more scholarship than I'm master of to understand.*

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* The reader should be warned that in order to ensure the vibration of a body through different distances in equal times, it is necessary that the vibrating body should describe, as it moves, a peculiar kind of curve, called a "cycloid," and that when the ordinary pendulum is made to swing a great distance, there will be a certain difference in the time occupied by its long and short vibrations; or, in other words, what is termed the isochronism (from ισος equal, and χρονος time) of the pendulum —the property by which all its vibrations, whether great or small, are performed in exactly the same period—*is true only for moderate distances;* and it *is* true only for such distances, because the pendulum in swinging describes the segment of a circle rather than the cycloidal curve before spoken of, and because the curve of the cycloid coincides for a short range only with that of the circle.

A cycloid is the curved line described by any point of a circle as it rolls along a straight line. For instance, a nail in the rim of a cart-wheel traces a cycloid in the air as the wheel rolls along the ground; or, if a hole be made towards the rim in the top of a pill-box, and the point of a pencil be introduced therein, the pencil will, if the lid be laid flat on a sheet of paper and made to revolve against the straight edge of a board, trace a cycloid on the paper as the top of the pill-box rolls along. Now the reason why the cycloid is what is termed an isochronous curve, is that it is precisely of that form which causes a body in descending one half of it to pass through a long space in the same time as a short one (owing to the increased acceleration of the force being exactly proportional to the increased distance it has to travel), and thus the body acquires, during its descent, sufficient force to enable it to ascend through an equal distance along the other half of the curve in an equal length of time.

I only know it does so; and what's more, that it requires a pendulum to be of a different length to swing seconds at different parts of the earth, and that if we went to Guinea in Afriky, the pendulum must be shortened to do as much as it did in England, for the same pendulum would give nearly 6 more swings in the hour in these parts than it would in those; so that a clock that went right here, would go too slow there, unless a little bit were taken off what you call the rod at the back. Now you mustn't bother me, Master Owen, with any of your questions about what's the reason of all this, for I can't tell you; it's beyond my learning, as I said before. All I know is, it depends upon what they call gravitation."

"Gravitation!" echoed the boy, thoughtfully. "I think that was the name of one of the forces Mr. Wynn spoke to me about; but I don't know what it means."

"Well, then, I'll tell you, lad," responded Roger Wilkins; "and there's a little story about that, too, which makes it all the better."

At the prospect of another tale, Owen sidled the inverted hamper on which he was seated close to Roger's knee, and looking up, fastened his eyes intently on the clothier.

"To begin," said Roger, "you must know, that what they call gravitation, is the force which gives weight to everything, and which makes us and all moving creatures stick to the ground; for if it

wasn't for that, we should tumble right off, and fall bump into the moon, may be."

"Ho! ho!" laughed the boy, "that *is* funny. But it's impossible for anything to fall *upwards*, Mr. Wilkins, and the moon is above us, you know."

"Very good, little master Clever," said the clothier, as he stooped down to pat the boy on the shoulder, "but suppose there isn't any such thing as up or down, no more than there is any back'ards or for-'ards in nature. Now look you here, I'm afore you now, aint I? Well, turn you round," and as he said so, Roger twisted Owen round on the hamper, "and where am I then? Why behind you, to be sure. So you see, for'ards is back'ards, all according as you're looking. Just you give me that ball of yarn there, out of the basket under the loom, my little man."

Owen having complied with the request, the clothier proceeded.

"Now this ball here, we'll call the earth, and this pin" (he drew one from the cuff of his jacket, where he kept a small row), "which I stick in at the top of the ball, we'll call Owen Evans, and this t'other pin, which I stick in at the bottom right under it, we'll call my cousin Tom, who's out in New Zealand. Well, now we'll hang the ball up to one of these straps here, and there it is," he added, when he had done so, "just like the earth, with Owen Evans on one side, and cousin Tom right under him on the tother. Now, can't you see, Owen, boy, down'ards to you

must be up'ards to Tom, in the same way as what's up'ards to you is down'ards to Tom; and that if Tom wasn't kept in his place, why he'd fall away right up as *he* would call it, for all the world as when I loosen the hold of this pin against the ball—away tumbles cousin Tom, you see, up or down just as you please, master Owen."

"But Mr. Wilkins," laughed the boy; "your cousin Tom would be going about with his body hanging down, just like the flies do on the ceiling."

"Yes, and little Owen Evans would be doing the same thing," returned Roger, smiling at the humour of the illustration,—"for look here, we will put one ball down on the ground, and another right up at the top here, close against the strap. Now, we'll suppose the one underneath the middle ball to be the sun, and the one up above it to be the moon, then, of course, it's day to cousin Tom, and night to Owen Evans. Well, we'll stick a pin in each of them balls, and we'll suppose the one to be that celebrated gentleman known as 'the man in the moon,' and t'other Mr. Any-body-you-please, in the sun; well, you see now, Tom would certainly seem to the gentleman in the sun, here, to be walking with his head down, but Owen Evans, too, would look as if he was practising the same difficult feat to the man in the moon."

The little fellow chuckled again with delight, as he saw the force of the illustration, and observed that he could now perceive that up and down were

only different ways of looking at a thing, the same as behind and before. "But is the earth round like a ball, if you please, Mr. Wilkins?" he inquired.

"Yes," returned Roger, "but we needn't trouble our heads about that now, for I want to tell you about gravitation; and one thing at a time is my maxim. Well, my boy," he proceeded, "gravitation is, as I said afore, the force that draws everything down to the earth, and that keeps them there when they are drawn down. Now I see, Owen, by the look of you, that you don't understand it. Well, you'd better run into the house, and fetch me that little magnet as I bought my youngsters; you'll find it in the kitchen drawer."

The lad scampered off, and returning in a minute or two, placed the magnet in the clothier's hands.

"This bit of iron at the end," said Roger Wilkins, is what is called 'the keeper.' Now, we'll tie a bit of thread to that, and hang it over one of these pulleys, in this way," chattered the clothier, as he performed the operation, "and then we'll fasten a bit of stick to t'other end, just to balance the keeper in the air—so, my man. Well, you see, Owen, directly I put this magnet a little way under the keeper, it pulls it down towards it, and makes it descend for all the world as if it were a stone dragged down to the earth."

"Is the earth then a magnet?" inquired Owen.

"That I can't say, lad," answered Roger, "and I didn't mean you to take what I was saying in that light at all; I only wanted to give you a notion how one thing might be attracted to another. Now, I dare say, boy, you fancy as it was the magnet that drew the keeper to it, and you'd be astonished if I showed you that the keeper drew the magnet as much as the magnet drew the keeper, or what is the same thing, that they both attracted one another. For look you, I have only to tie the magnet to one end of the string, instead of the keeper, and put a heavier bit of wood at the other end to balance it over the pulley, when you'll see if I hold the keeper underneath, the magnet itself will be attracted. Look you there, Owen! Didn't you see the magnet descend?" cried Roger, as the little red horse-shoe was drawn down to the piece of iron beneath it.

"But surely, Mr. Wilkins, you can't mean to say that the stone attracts the earth as well as the earth attracts the stone towards it?" interrogated the eager boy.

"Yes, I do, youngster," retorted the clothier, nodding his head at the little fellow; "and the reason why the stone only moves is because it's easier for the earth to move the stone than for the stone to move the earth."

"Oh, I see what you mean now, sir, and I think I understand it thoroughly, thank you," said Owen, as he pressed Roger's hand in his.

"Now, Owen, suppose I was to tie a number of these magnets round a small hoop, so that the poles or ends of 'em stood up all round the edge; then suppose I was to tie some more magnets in the same manner round another hoop, and to put the one hoop through the t'other so that it stood right across it; and then suppose again, I took two more hoops with magnets all round them like the others, and passed them in the same manner through the t'other two, so that the whole of the hoops together, crossing one another, should form the skeleton of a ball. Well, if I were to cover this all over with anything, I should have a perfect ball of magnets, you know; and then, if we were to roll it in a lot of iron filings, we should find the little bits of iron would cling all round the ball, so that you might hang it up in the air without one of them dropping off; and there you'd have a perfect little model of the earth, with all the things on its surface, held to it by the force of attraction. Now do you understand it, lad? but *mind*, you must remember that the earth attracts everything,—stones, and men, and trees, and water, just the same as the magnets do the iron filings."

"Oh, yes, I understand it perfectly, Mr. Wilkins," said Owen, "but please, sir, you've forgotten the story."

"No, young Impatience, I haven't," replied the clothier, good humouredly, "but I was obliged to make you comprehend about gravitation before you'd

be able to comprehend about that. Well, now, as I think you know all concerning the force as draws things down to the earth, and so makes them feel heavy to us, I'm going to tell you what a boy named Isaac Newton did. His father, you must know, was a farmer at Woolsthrope, in Lincolnshire, and when he was a lad he used to make models of windmills. It was he, Owen, as invented paper kites, and the little monkey used to take delight in sending them up on dark nights, with a lantern at their tail, and frightening all the villagers round about out of their wits, by making them believe as they were great comets. While he was at school, at Grantham, too, he made a sun-dial by watching the movements of the shadows throughout the day, and this was long known in the town by the name of 'Isaac's dial.' Well, my boy, they wanted to make a farmer of little Isaac, so he was took away from school and sent to Grantham Market with the old farm servant, to sell the things; but instead of striving to get the best price for the corn and bargaining with the cattle dealers, the young rascal used to stay outside the town and sit under a tree by the road-side, studying some book until the old servant returned."

"Well, I do think, do you know, Mr. Wilkins, that I should have done the same," said the simple-minded Owen.

"No doubt you would, you little rogue," tittered

the clothier. "So one market-day, as Master Isaac lay stretched on a bank reading some book, a little way out of the town, who should come by," continued Roger, between the puffs of his pipe, "but his uncle, who was the rector of one of the parishes hard by; but the boy was so took up with what he was a-studying, that he actually didn't know any one was nigh—right at his elbow—a-looking over his book. His uncle was astonished to find Isaac was engaged in larning about angles and circles and such like. Luckily though, the rector was a sensible kind of a man, so he advised the boy's mother and step-father (for Isaac's own father had been dead many years) to send him to college, saying as a boy like him wasn't fit to look after ploughing and reaping and such like. Well, Isaac went to college, and stayed there, larning and larning, until the plague broke out—that was a dreadful disease, which killed thousands a week, Owen—and then he was obliged to leave Cambridge and go back to the farm at Woolsthorpe. Now it was while he was there one day, sitting under one of the trees in the orchard, that young Isaac saw an apple drop from one of the boughs to the ground. He knew it was gravitation as made the pippin fall; for though some people fancy he discovered *that*, it wasn't no such thing, because the force as draws things down to the earth was known long afore his time. Well, Isaac says to himself, says he, as he lay in the shade, a-twisting and a-turning the matter over in

his mind, 'since it's the attraction of the earth as pulls that there apple down to the ground, and since if I was to go up to the top of the highest buildings and the peaks of the loftiest mountains the attraction of the earth would do the same thing there, and it's the same force again which makes the hailstones and the raindrops fall down from the clouds, *where does it end?*' And then Isaac asked himself whether there could be any point where the attraction of the earth would cease? and if there was no such point, why then of course the attraction must reach to the moon, and be pulling that down to the earth all the same as if it were an apple or a stone."

"Oh! but, Mr. Wilkins, that can't be," cried Owen, starting up.

"Yes, but it *can*, sir," returned Roger, "and what's more, Isaac went to work and proved by figures that the moon *is* continually being drawn down to the earth, and that by the very same force as draws the stone to the ground. He showed, too, that's why the moon goes on revolving and revolving round about our globe; and not only is the force of gravitation the cause of the moon revolving about the earth, but he proved as it was the very same power that made the earth itself and all the planets revolve about the sun. But that's not what we're about, Owen;" continued the good-humoured clothier, "I was showing you how it's the force of gravity as makes

all bodies feel heavy to us. Now it's by the length of the pendulum that clever men measure this force at different parts of the earth; and strange, I dare say, as it will seem to you, they've found out that bodies get heavier as they *come to us* from the south, and heavier still as they *go from us* towards the north; that is to say, a pound weight on the coast of Guinea, in Afriky, is less than a pound weight here—so much so indeed, that 1000 pounds in *these* parts would weigh as much as 1003¼ pounds in *those*. For the same pendulum as swings once every second there, and so makes 86,400 such swings in a day, would, when carried to London, make 135 more swings in the course of 24 hours, or 86,535 in the same time.*

* The reason why the force of gravity becomes greater as we proceed from the equator to the poles is, that the parts of the earth's surface at the equator revolve at the rate of about 1000 miles an hour; whereas, the poles themselves being fixed points, or extremities of the axis on which the earth turns, can have no revolution whatever; and the parts of a revolving body acquire a greater or less tendency to fly *from* the centre, in proportion to the rate of revolution. Consequently, where the rate of revolution is the greatest, the parts of the earth must have the least tendency *towards* the centre, and therefore gravitation, (which is merely the force giving bodies at the surface a tendency *to* the centre,) must be diminished in proportion as the rate of revolution, or the force giving them a tendency to fly *from* it, is increased. The amount of the force urging bodies *from* the centre of the earth at the equator is found to amount to the 289th part of their weight; or, in other words, of the force urging them *to* it. The former is called the "*centri-fugal* or (centre-fleeing) *force*," and the latter the "*centri-petal* or centre-seeking) *force*."

Now as it's the force of gravitation alone, my boy, as makes the pendulum swing, it's very clear that where it swings the quickest the power must be greatest; and it's because the pendulum swings faster in London than it does on the coast of Guinea, that the weight of a London pound must be more than an African one."*

"But, Mr. Wilkins," said Owen, "I can't make out how you can tell *that;* for if every pound in London is so much heavier than every pound in Africa, how could you find out the difference? Suppose you were to weigh a pound of sugar on the coast of Guinea, as you call it, and to bring it to England, it would still be a pound; for though it might have become heavier, the pound weight, I suppose, would have got just as much heavier too?"

"There's a clever little man!" smiled the clothier, "for you're quite right in what you say, and the difference couldn't be come at by any such means.

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* The following is the rule by which to *measure the force of gravity at any place by means of a pendulum of a certain length:*

Divide the length of the pendulum by the square of the number of times it beats in every second, and multiply the quotient by 9·8696.

To find the length of a pendulum which shall swing a certain number of times in a second, the rule is as follows:

Multiply the square of the number of seconds by 3·2616.

While *to find the number of times a pendulum of a certain length will swing in a second,—*

Multiply ·55372 by the square root of the length.

But suppose, Owen, we were to have a pulley rigged up atop of a high post at the equator, and another pulley atop of another high post at the North Pole, with a long cord reaching from the one to t'other, and an equal weight at each end of it. I say, *suppose* we were able to rig up such a bit of machinery as that —for it wouldn't be possible to do it, you see—then we should find that the weight at the North Pole would lift the weight at the equator, and we should have to add the twelfth part of an ounce to each pound at the equator to make it balance the same number of pounds at the pole. There, give me the chalk, and I'll soon let you see what I mean." Whereupon Roger went down on his knees once more, and described the following figure on the floor.

"Now, you see, Owey," continued the clothier, "that's meant for the earth, with the pulleys I spoke of rigged up on it—one at the equator, another at the pole, and a third, we'll say, at London. Well, then, if there was a cord passing over them pulleys,

and a weight fastened at each end of it, we should find that exactly 195 pounds would be needed at the equator to balance 194 pounds at the pole, for every one of the pounds at the pole would be, as I said afore, just about $\frac{1}{12}$th of an ounce heavier than each pound at the equator. But, though 194 pounds at the pole would balance 195 pounds at the equator, about 194 pounds 6 ounces would be required to do the same thing at London. Now do you understand?"

"Yes, I understand what you mean, sir," returned the lad; "but you yourself say it wouldn't be possible to tell the difference in weight in that way."

"Very true, lad," was the reply, "but there are other modes of weighing bodies, you see. For instance, we can find out how heavy things are by the pressure they exert on a spring, and scales are very often made in that way now-a-days, for they don't require any weights, and so come very handy. Accordingly, with a spring weighing-dial the index would show us that a pound at the equator really grew heavier as it was carried to'ards either of the poles. Still, it's by means of the pendulum that the difference in the force of gravitation at different parts of the earth is found out, for where the pendulum swings the fastest, as I said afore, the power must be the greatest, since it's only gravity as makes it swing at all."

"But how is it, Mr. Wilkins," asked Owen, "that

the force of gravitation, as you call it, makes the pendulum swing? for gravitation drew the apple *straight* down to the earth, but the pendulum moves *backwards and forwards*, and that can't be the same as the other."

"Ah! I thought you'd be about *that*," smiled the clothier. "Well, now, my little fellow, I must have a bit of chalk and a clear space—here on the floor will do."

Accordingly Roger Wilkins knelt down, and having dusted the boards with his apron, described the following figure, but much larger than here represented.

"There, my lad," said Roger, "we'll suppose the straight line down the middle to represent the pendulum in a state of rest, and the slanting dotted lines to be the pendulum in its two farthest positions as it swings back'ards and for'ards. I've

ROGER WILKINS EXPLAINS THE THEORY OF GRAVITATION.—Page 136.

made it three feet and a quarter long, because I told you afore that is the length as swings once every second in this country; and the round mark I've made at the end of the rod we'll imagine to be the 'bob,' or weight. Well, now, Owen, we'll fancy the pendulum to be lifted slightly up on one side, and to be in the position shown by the dotted line on the right. Then, of course, the weight being attracted to the earth, wants to come down to the ground, but it's held by the rod, you know, and this again is supported by the point it swings upon, so that as the weight falls it is carried along by the rod from C to B. But by the time it gets to that point, it is plain that it has fallen from the level of C to that of E, or, in other words, through a perpendicular space equal to the line CE. Then the force which it hasgot in its descent through that space is strong enough to carry it up to an equal height on the other side. But in *ascending* through this space it has to overcome the natural tendency of the weight to *descend*, so it is evident that by the time it gets to D the whole of the force which it had gained in falling *down* the first half of the curve will have been spent in driving the weight *up* the other half of it. Whereupon it will begin to fall again, and so descend through the perpendicular space DF; but in falling *down* this half of the curve it will get force enough again to drive it *up* the other half, where the acquired force being once more ex-

pended, it will begin to descend a third time; and so it will keep on swinging back'ards and for-'ards until the friction of the point it hangs upon brings it to a standstill. And now, my little man, you can perhaps see how a weight can fall down and yet swing back'ards and fora'rds at the same time."*

"Yes, Mr. Wilkins, I do, indeed," answered the delighted boy, "and I fancy I can almost see, by the motion of the pendulum, how gravitation could make a body that was continually falling move round in a circle, as you say Isaac Newton showed was the case with the moon."

"Well, well, we'll talk of that another time," ejaculated Roger; "there's one more experiment I want to show you, and then we shall be ready to understand all about the clock. I want to show you, Owen, that a pendulum of a certain length really *does* swing once every second. Now, what was the length that I said the pendulum should be to do so?"

"Three feet and a quarter," answered Owen, briskly, and not a little proud of his knowledge.

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* It will be borne in mind that the isochronous property of the pendulum is true only for very small portions of *circular* curves; the *cycloidal* curve alone being of such a nature that the weight of the pendulum, in descending through a large arc, has its motion *just as much accelerated as that arc is greater than a small one*, so that it falls through long and short spaces in the same time.

"There's a fine little fellow," said Roger Wilkins, as he pressed the boy encouragingly to him, "it's quite a pleasure to teach an attentive lad like you. Now let's measure the pendulum to the clock here. I've got my foot rule in my pocket," he proceeded, as he withdrew the measure and applied it to the instrument. "There's one foot, Owey," he said—"two foot—three foot, and three inches just about. Now, how are we to tell at what rate the pendulum swings?"

"By hanging it up at the back of the clock and counting how many swings it makes in a minute," cried Owen, as quickly as he could, for the previous praise had made him anxious to display his little knowledge once more.

The clothier stretched out his legs, and stood looking at the boy for a minute or two; then he shook his head at him, and said, "No, no, sir, you're out this time, and a good way out too. You're a pretty fellow! you'd be putting the cart before the horse with a vengeance. Didn't I tell you that a clock was a piece of machinery merely for marking the beats of a pendulum, and here you'd go and use the clock to tell whether the pendulum beats rightly or no! Why, if the pendulum, Owey, beats too quick or too slow, of course the clock must go too quick or slow as well."

The boy bit his fingers with vexation at the mistake he saw he had committed.

"Well, never mind, lad," said the good-humoured Roger, "there's a better way of doing it by far. You've a watch about you that'll do nicely."

"No, I haven't, sir, indeed and indeed," exclaimed the astonished little fellow, as he instinctively looked down towards his pockets.

"Oh, yes, you have!" returned the clothier, laughing, "you've got one in your wrist."

"In my wrist," echoed Owen, almost bewildered by the information, and turning up his cuff as if he expected to see a pair of hands there besides his own.

"There, there, boy, I mean your pulse," added Roger; "*that's* the watch Galileo used in order to time the beats of the pendulum, when he first discovered the law of it, and surely the same timepiece as *he* worked with will answer *our* purpose. Now, Owen, we'll hang up the pendulum by itself on this hook, and you shall count the vibrations up to sixty—that'll be just a minute, you know—while I'll reckon the beats of my pulse up to seventy-five, for that's the number of pulsations which occur in a full-grown man in the same time. Mind, we must both start at the same moment, and repeat the numbers silently to ourselves," said Roger Wilkins, as he placed his fore finger on his wrist, and bade Owen touch the pendulum gently and begin to count the swings immediately it commenced vibrating.

The boy having raised the "bob" slightly on one side, let it fall from his fingers, and the moment

after, the lips of both Owen and Roger Wilkins might be seen moving as the clock ticked.

"Sixty!" presently shouted Owen.

"Seventy-five!" roared Roger Wilkins, at the same moment. "There, my boy," he added, "we have done what young Galileo did near upon three hundred years ago. Well, that point is settled at last; and all we want to understand now is, how we are to keep the pendulum swinging, and how many teeth we want in the wheels to make the hands mark the minutes and the hours. It's lucky for you, I'm thinking, my man," added the clothier, "that the stream is dry, or I never should have had time to have given you this lesson."

"No, that you wouldn't, Mr. Wilkins," answered Owen, "and I'm very much obliged to you, I'm sure."

"Now, my boy, to know all about the works of the clock, we must have the doors off. In Dutch clocks like this, they are made to hook on at the side, and can be taken off without hurting the clock in any way."

The sides then having been removed, and the works exposed to view,* the clothier proceeded to explain to Owen the uses of the various wheels.

"This wheel at the bottom," he said, "is what is called 'the great wheel.' In most clocks it's made to drive the hour hand, but here it moves the minute hand, and the consequence is, that clocks like these

* See Engraving at p. 162.

have to be wound up every day; for you see, Owen, there's a pulley on the axle of the great wheel, and as the weight descends, it forces the axle round; then this axle runs right through to the face of the clock, and has the minute hand fixed on to the end of it, outside the dial, so, of course, as it revolves, it carries the minute hand round with it. Now, the minute-hand goes round once in how often?"

"In every hour, isn't it?" inquired the boy.

"Yes, that's quite right," continued Roger. "And how many times does it go round in the course of the day, then?"

"Twenty-four times," was the lad's answer.

"Well, Owen, since it's the weight as makes the minute hand turn round, of course the string, that the weight is hung to, must be twenty-four times as long as the pulley, that the string passes over, is round. You understand that part, my lad?"

Owen nodded assent.

"But in clocks that go a long time," added the, clothier, "the weight is made to tur n the hour hand and as that revolves only twice a day, of course the weight in such clocks has a less space to fall through, and so the same length of string will keep the clock a-going a longer time. But all we've got to do with at present, is with clocks like this one, as need to be wound up once every twenty-four hours. Well, as I was a-saying, the weight here pulls the axle of the minute hand round; and now what we want to

know is, how to make that axle, while revolving once every hour, move the pendulum once every second. Let us see then, lad. How many minutes are there in the hour?"

"Sixty," returned Owen. "I know that, because I can see the number marked over the twelve on the dial.

"Yes, that's right," proceeded Roger Wilkins; "and there are sixty seconds in every minute. Now, boy, if we multiply 60 by 60, we shall have 3600 for the number of times that the pendulum must swing while the axle of the minute hand turns once round. Well, the use of these wheels here, which you see placed above the great one at the bottom, is merely to make the pendulum swing once every second, as the minute hand revolves once every hour."

"I could never do that," exclaimed Owen.

"Come, look here, my boy," said the clothier, pointing to the great wheel. "On the axle of the minute hand there is, you see, a cogged wheel, and that wheel has got 70 cogs or teeth to it. Now, those teeth, as the wheel goes round, work into the little pinion, which is fixed on the axle just above it; and as that pinion has got 7 teeth, and the wheel working into it 70, it's very plain that the middle axle must turn 10 times quicker than the bottom one; so, of course, the middle wheel must go round once every 6 minutes, while the great

wheel at the bottom, or that which turns the minute hand, goes round once every hour."

"Of course it must," said Owen.

"Then again," Roger went on; "there's another cogged wheel, you see, on the middle axle,* and it's 70 cogs or teeth to it as well. Now this works into another pinion on the axle above it, which has got 7 teeth like the t'other, so, of course, the top axle turns round 10 times as quick again as the middle one does. Well, the middle axle revolved once in how many minutes, Owen?"

"Six, sir," was the reply.

"Very good," responded Wilkins; "and as the top axle turns 10 times while the middle one turns once, you would find, if you counted it, that the top axle must go round once in every 36 seconds.

"Oh! thank you, sir," replied Owen; "it's rather difficult for me to follow the figures, but I can understand quite well how it's done."

"Yes, it's all simple enough, lad, when you can reckon it," replied the clothier. "But where had we got to?—oh, we left off at the top axle. Well, on that axle is placed what is called the ''scape' or 'escape' wheel, that is to say, a wheel with the teeth cut slanting, like those of a saw. Now, this 'scape wheel has 36 teeth round its edge, and each of these teeth causes one or other of the 'pallets'—

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* See Engraving at p. 162.

they're little strips of brass with ends bent inwards, something like the flukes of an anchor, fastened to the axle of the pendulum—to rise as it slides under them, so that it isn't very difficult to see that the pendulum must make 36 swings while the axle of the 'scape wheel goes round once."

"To be sure it must," said little Owen Evans; "and now it's all done, and I needn't trouble you any more, Mr. Wilkins."

"No, no, no; not quite so hasty, youngster," smiled Roger; "you've forgotten all about the hour hand, and I don't see exactly how you could have a clock to tell the hours without any hour hand."

The boy laughed, but with a poor grace, at his own mistake.

"Well, that's not very difficult, Owey, and wont cost us much time or trouble to understand," remarked the clothier. "On the axle of the great wheel at the bottom—which you know is the one as carries the minute hand round, and revolves once in every hour—there is a small wheel which has 24 cogs to it. Well, this works into another wheel above it, which has the same number of cogs round it, so of course the axle of this wheel revolves at the same rate as that of the great wheel axle. Now, the upper wheel has on its axle a pinion with only 4 teeth to it, and that pinion works into another wheel with 48 teeth; so then, you see, the wheel with the 48 teeth must go round

once while the pinion above it goes round 12 times; and as that pinion turns at the same rate as the axle of the minute-hand does, it's clear that the axle of the 48-toothed wheel must revolve 12 times as slow as that of the minute-hand. Now look, boy; the axle of the 48-toothed wheel is hollow, and carries the hour hand at the end of it outside the dial, while that of the minute hand passes right through it, and has the long hand fixed to the end of it in the same manner. There, my little man, you know now all I can tell you about the clock. However, so that you may make no mistake, I'll just mark down the numbers of cogs to the wheels on a bit of paper for you, and then you can toddle and make a clock for yourself as quick as you please."

"Oh! thank you, Mr. Wilkins; I'm sure you're very good," observed Owen; "I don't know what I should have done if it hadn't been for you."

"There, never mind about your thanks," said Roger, "I'm too glad to teach you the little I know whenever I've got the time to spare. You come in again some day, my little man, and then I'll tell you about Benjamin Franklin, a poor printer's boy, who used never to touch a bit of meat, so that he might live upon less, and buy books with what he saved. And I'll tell you how he got to be the first man in America —became a kind of king there—and how he brought down the lightning from the skies by means of a

kite. What do you think of that, Owey? But come, it's no use your stopping there with your mouth wide open, for I'm tired out, and so ought you to be, I'm sure, you voracious young scaramouch, you;" and as the clothier said this, he threw his arms about the boy, and pressed him to him. "There, go along, *do*," cried Roger, "or else you'll be dragging another story out of me; but I've got a fresh warp to put into the loom, and if I'm not much mistaken, we shall have rain afore the morning, for I noticed, a little while ago, that the flower of the chickweed was closed, and that's as good as a weather glass any day. It's the poor man's barometer like, and will tell you when the weather's a-going to be 'showery,' and when it will be 'very wet,' as well as the best glass you could buy. I shall be at work again, I hope, to-morrow. So, run away as quick as you can, my little fellow, and let me see your clock when you've made it."

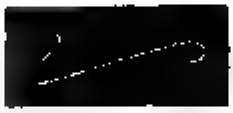
CHAPTER V.

OWEN'S DIAL.

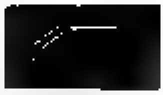
OWEN was too full of his clock to turn to any other occupation, and although he had tired out the clothier, his own interest in the subject was in no way abated; indeed, now that he was better acquainted with the various parts of the machine, he felt, if possible, more eager than ever to get to work at it.

The first thing the boy did was to pick out from the lumber in the tool shed, a piece of hard wood, out of which he could cut the wheels and axles of his timepiece. And when he had planed it smooth, and reduced it to about an eighth of an inch in thickness, he made the great wheel, (2 inches in diameter) cutting out the teeth with his penknife, in the form here shown—

Then he got a bit of wire, and bent it into the form of a spring, thus—



After this he cut out the "click."



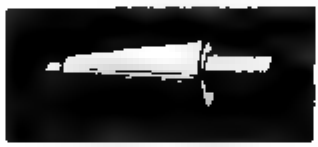
And when he had finished all these, he proceeded to fix the click and the spring to the rim of the great wheel in this fashion—

Next, he got a stouter piece of wood, about half an inch thick and near upon two inches square, and out of this he carved the pulley or "barrel" to carry the cord—cutting a deep groove in it, and notching it all round the edges so that the cord should not slip. On one side of the edge of this, too, he made the ratchets for the click on the large wheel to work into. And when he had completed the pulley it assumed this shape—

Now came the axle, or "arbour," as it is technically termed, on which the great wheel and the pulley were to be fixed, and this was after the manner of the annexed.

That done, he constructed the little wheel that was to work another of the same size, whose pinion was to move the hour hand, and made it thus—

Presently he set to work at the axle, or arbour, to carry this wheel, which he formed after this fashion—



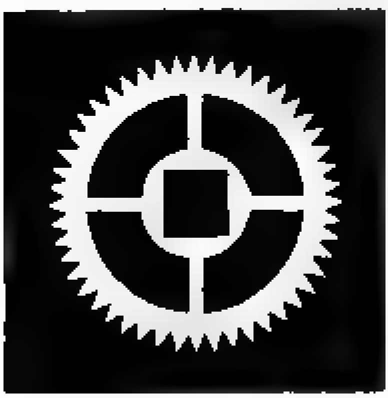
And having fixed the small wheel upon it, the wheel and arbour appeared as here represented—

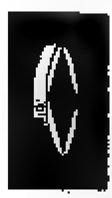
The next point was to join the two parts of the axle together, by inserting the small square end of the first into the square hole at the extremity of the second, and when the two were united they looked like this—the whole being about 3 inches long.

Owen then made a wooden nut or collar, with a

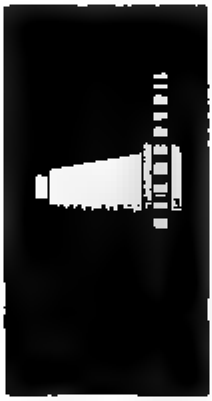
hole in the middle to fix at the end of the axle, and to keep the great wheel tight in its place. When he had completed this, he proceeded to fix the pulley and the great wheel in the manner here shown, putting a piece of cord over the pulley to see how it would work.

He afterwards occupied himself with making the wheel to drive the hour hand. The axle to this was hollow, so as to pass over that of the minute band, and there was a little nut wherewith to fix the wheel upon it—each as given below.





And when these were put together, they had the following appearance.

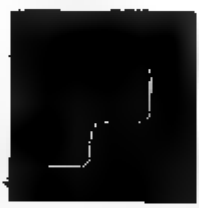


After this the boy passed the hollow axle of the hour hand over that of the minute hand, arranging them as shown in the subjoined engraving.

The delighted lad here paused for a while to contemplate his handiwork; and as he twisted it round and round, he inwardly wondered what Roger Wilkins would think of it. Then the boy longed for the moment when it would be finished, and he could hear it go "tick, tick," for the first time.

In a few minutes Owen was hard at work again, making the stanchion or bearings for the great wheel. This part of the machine he fashioned out of a bit of wood ¼ of an inch thick, 1 inch wide, and 4⅝ inches high. One inch from the bottom he bored a hole half an inch across, and made three other small holes above it to carry the axles of the upper wheels,—drilling these at the places indicated in the engraving here given.

The moment after, the boy was busy making another wheel an inch in diameter, with twenty-four teeth round its edge, similar to the one he had previously formed; and close round the centre of this he fixed four bits of wire to serve as the teeth of a pinion. That done, he pointed a stout bit of wire about a quarter of an inch long, and drove it into the lowest of the small holes he had made in the stanchion. This was to serve as a pin for the inch wheel he had just formed to turn upon. Next he bent another bit of wire into this form—



That was to serve as a stay to the inch wheel, so as to keep it in its place; and having pointed the end of it, he drove this into the stanchion as

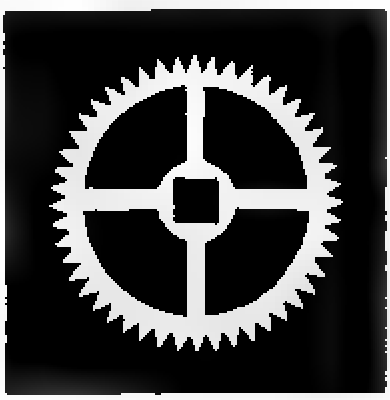
well, about an inch above the other. Then he placed the wheel upon the wire axle, and brought the stay down before it in such a manner, that, when the two were fixed on the stanchion, the wheel with its stay appeared as here shown.

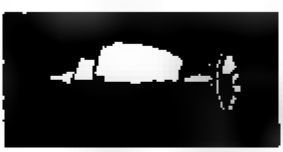
After this, Owen commenced making the hands for the clock, which he did as follows:

These finished, he undid the axle of the minute hand, at the joint in the middle of it, and having

passed it through the hole in the stanchion, put it together again. Then having fixed the hands on the ends of the minute and hour axles, the boy once more paused to contemplate the look of the whole.

All that now remained to be done were the wheels to drive the pendulum. The middle one of these, (which was 2 inches in diameter,) with its axle, pinion, and nut, he made in this wise—





And these he put together thus—the whole being a fraction more than 2 inches long.

Next came the 'scape wheel, axle, nut, and pinion;* these he made of the same size as those on the middle wheel.

Presently the boy was busy fashioning another stanchion, but this was $5\frac{1}{4}$ inches long; for it

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* The pinions are what are termed "lantern" ones, and consist merely of 7 straight pieces of wire set round the axle as shown in the engravings.

was to be let into the top and bottom of the frame. At the upper part of it he bored a large hole, so as to allow the axle of the pendulum crutch to pass through it; and he drilled three small holes down it so as to serve as bearings for the axles of the 'scape, middle, and great wheels. When he had fitted the several axles into their respective places, the whole of the wheels put together appeared as under—

Then came the frame. For this he made four small supports, out of a piece of $\frac{3}{8}$ stuff, each half an inch wide, and $4\frac{1}{2}$ inches high; after which he

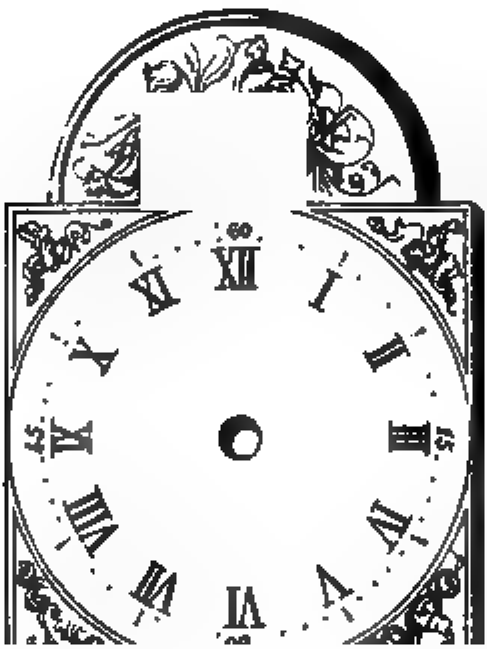
fashioned the top and bottom, making them each $3\frac{3}{4}$ square, and piercing holes in them to receive the rounded ends of the four supports; and when he had nailed the whole together, it was as here given—the hook at the top of the front support being placed there as a means of fastening the dial to the frame.

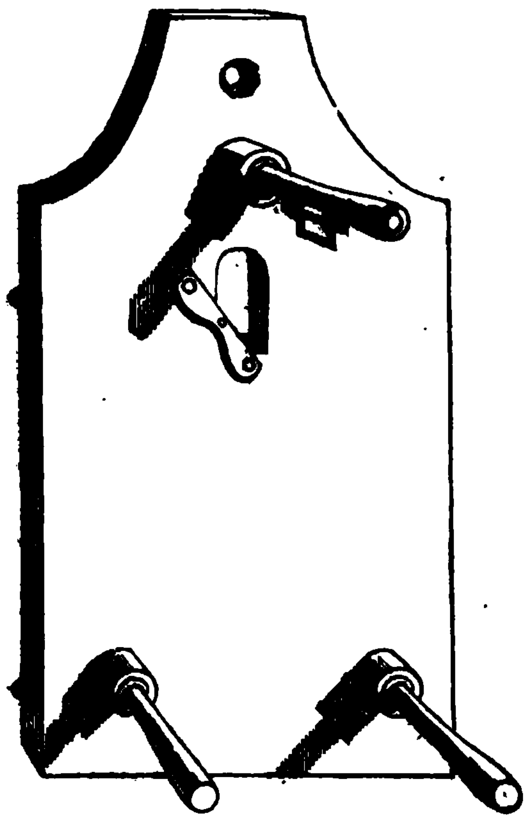
Owen had now to construct only the pendulum crutch, and "pallets," in order to complete the works,

and as these were comparatively easy, he was not long in making the following:

Nor when these were completed, did it take many minutes to fix them, thus—

Everything was now finished but the back and front. The dial, however, cost the boy more trouble than all the works put together. The face of Roger Wilkins' clock had a bunch of flowers, Owen knew, at the top, and some ornaments in each corner. For a long time he could not tell how he was to manage this so as to make it look anything like the clothier's. However, he chanced at last to light upon a bit of old chintz curtain, whence he cut out the desired bunches of flowers; then gluing them to the top of the dial, the face of the clock, when he had finished it, was not very unlike that of the old Dutch clock at the mill.





After this the boy formed the back, thus—

The hole at the top of the back was to hang the clock upon its hook; the wooden peg projecting immediately beneath the upper hole, with the bent wire below it, was to suspend the pendulum from; and the hole underneath this was to allow the crutch to pass through; while the little tin plate at the side of it, with a small hole drilled in the middle, was to serve, when fixed, as a bearing for one end of the pendulum axle, the other end of which was made to work in an eyelet hole at the bottom of a strip of metal let through the top part of the frame; lastly, the two pegs at the bottom were to keep the clock from the wall.

Owen was not long, now that he had progressed thus far, in fixing the back and front to the frame. The back he nailed to the top and bottom, but the front (as he might have occasion to remove it) he fastened by means of a hook attached to each of the foremost supports at the side.

At length, however, the back and front were added

to the other parts, when the whole appeared as here drawn.

The clock was now complete, with the exception of the side doors to close the works in and keep them from the dust. As these were merely flat bits

of wood ($3\frac{1}{8}$ inches by $5\frac{1}{8}$), it did not take long to form them. The hinges were made of two bits of bent wire, which worked into two wire eyelet holes let into the back; and there was a hook fixed to the front part of the doors to fasten them to the frame. The doors were soon fixed, and the clock—with the pendulum and weights added—hanging against the wall.

The timepiece once finished, and placed upon its hook, Owen's hand trembled with excitement as he pushed the pendulum and caught the sound of its first "tick," after his many days' labour. Then he ran back and stood gazing at it,

chuckling inwardly as he beheld the rod swing gently to and fro, and heard it throb again, almost like the beating of his own heart. The little fellow sat half the day in his own room looking at the little machine, and playing with it — now mounting the chest of drawers that stood beside it, and opening its little wooden doors, so that he might see the wheels turn round, and the pallets move up and down as it went—then fancying that some of the bearings were too loose, and taking it down to make the imaginary improvements. When these were completed, and the timepiece was once more in its place, the delighted boy would try all kinds of experiments with it—at one time he would unhook the pendulum, and laugh again as he heard the "ticking" quickened, and the pallets rattle against the 'scape wheel—at another, he would slide the pendulum "bob," as it is called, up the rod, and see what difference the change made in the rate of going.

Presently, as Owen saw the minute hand come round for the first time to the point of XII, he thought to himself he should like to make it strike. It would be so nice to hear it speak to him as it were, and tell him how the hours went by. He sat for a while considering how he could do so. It would not be very difficult, he thought, to make it sound one at every hour, and that would be quite enough for what he wanted. He would only

have to put a pin in the pulley that was on the axle of the minute hand, and as that revolved once every hour, the pin could be made to force up the bent end of a long hammer, and so drive the top part back; then there could be a spring placed behind this, so that when the bent end was released from the pin, the upper part should be pulled suddenly forward, and made to strike against something that would give a sound.

But what that something was to be, was more than Owen could tell at that moment. Accordingly the lad fell into a reverie again, puzzling his brains as to what he could possibly use for a bell.

At length he thought he might be able to manage the matter with the neck of an old bottle. He remembered there was one in the tool-shed, and glasses he knew sounded beautifully.

The boy was not long in removing the jagged edges of the broken bottle by chipping it carefully round with a pair of shears, for he had often seen his father cut glass in that manner; after which he ground the bottom on a flat stone with a little fine sand and water. Then he took the clock to pieces once more, and proceeded to set the pin upon the front of the pulley on the lower axle, placing it as near the edge as possible. Next he formed the wooden hammer with the bent end, after this fashion,

and made the shaft long enough to project two or three inches above the top of the clock, in which he cut a slit so as to admit of the shaft working backwards and forwards. Then he had to search for something he could use as a spring in order to make the top of the hammer fly suddenly back against the bottle when the tail slipped from the pin. This part of the apparatus, however, he got from an old bird-cage; and then having corked the neck of the bottle tight up, he passed the end of the peg which he had set up, as a support for the bell on top of the clock, through the cork, and so fixed the bottle firmly in its place.

The timepiece once more against the wall, Owen was overjoyed with his work. As he watched the minute hand creep round gently towards the last point in the hour, he jumped on a chair in order to see the head of the hammer forced back, and there the boy stood, breathing quickly with the excitement, till he beheld the hammer spring suddenly forwards, and striking the side of the glass, heard it fill the little room with a sharp hum.

The little fellow was too impatient to be able to wait until another hour had passed away, second by second; so he took the pendulum off to make the wheels work quicker, and sat gazing at the hands

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OWEN SHOWS HIS CLOCK TO HIS FATHER.—Page 167.

as they ran round, and listening to the sound of the bell, as circle after circle was completed.

At length, however, the novelty wore off, and Owen grew eager for his father's return from work, so that he might show him what he had made.

And when the lad led his parent up to his room, and showed him the result of his labour, ticking against the wall, he felt more than repaid for all his toil, to find his father almost wonder-stricken at the work.

Davy Evans minutely examined every part of the clock, and when he had done so, he hugged the boy to him, and made the little fellow blush again with pleasure, as he praised his cleverness, saying it was more than he himself could have done. Whereupon Owen, glad to display his knowledge, explained to his father the use of the pendulum, and the reason he had made it of such a length. He repeated to him, too, the story of its original discovery by the young Florentine student—Davy Evans all the while smiling with pride at the lad's information.

"You see, Owey boy, I must come to learn of you, now," said Davy, as he curled his arm round the lad's neck, and pressed his palm fondly against his cheek. "Well, I'll tell you what I'll do, my little clock-maker, I'll give you an order. You shall make *me* a clock, and when you've finished it, I'll pay

you for it just the same as if you were in business for yourself."

"But I made *this one* for you, father," said Owen, as he kissed him, and hid his head against his cheek.

"There's a good fond lad!" added Davy, "Well, then, I'll pay you for that."

"No, father, don't do so," replied the son, "for it will seem as if I had done it for the money, and instead of that I thought you would keep it, and prize it when I had grown a big man, and was out in the world at work—perhaps away from you," (the little fellow's eyes filled with tears at the thought,) "the same as Mr. Wilkins told me they did at Grantham—I think that was the name of the place—with the dial Isaac Newton made when he was a boy. It was known in the village a long time after he died, by the name of 'Isaac's dial,' father."

"Well, boy," returned Davy, "we'll call this 'Owen's dial,' and we'll have it taken care of in the same manner that Isaac's was; I'll paint your name at the bottom of it too, and how old you were when you made it."

"No! will you, father?" exclaimed Owen.

"Yes, my lad, and what's more, when I go over to Llangoed again, I'll tell squire Macnamara there what you've done, and may-be he'll give you a job to clean one of his clocks, or perhaps to make a new one for the Lodge. Then, you see,

Owey, you'll be getting a little money for yourself, and wont you be proud of *that?* I remember the first sixpence I ever earned seemed to me the most beautiful bit of money in the world. It told me like, as I was growing a man, and getting able to shift for myself; for after all, lad, there's nothing like self-reliance in life. It makes all the difference betwixt an independent man and a beggar. Now, by an independent man, Owey, I don't mean one who is so rich as to have no need to work for his own living, for such a man is the most dependent of all creatures, and can't do a thing for himself. But what I do mean, lad, is a man who is able to support himself by his own labour. So, it's to make you have this faith in yourself, that I mean to pay you for the clock, and let you see that, even little fellow as you are, you can earn something. I can't afford, though, you see, lad, to pay you the full price, for I couldn't have spared the money to buy such a thing for myself; but, come, there's a new shilling for you," he added, as he drew from his pocket the little leather bag in which he kept his money, "and remember it a'n't a gift, boy, but what you've fairly earned."

Owen flung himself upon his father's neck, and kissed him again and again with delight. "Yes, father," he cried, as his head rested on Davy's shoulder, "I wish you *would* let me do something, —go out to work somewhere, and get a little money

for myself. I'm sure I'm big enough. I could mind sheep at least, if I could do nothing else. I've often wanted to ask you to put me out, for I know how hard you have to labour for all you get, and there would be so much the more for you if I could earn a little."

"Well, good lad," replied Davy, patting him on the cheek, "if you will, you *shall* be a little shepherd. The work isn't hard, and you can study while you're out in the fields; but, remember! you musn't get studying too deep, or you'd be having your sheep go astray, and that would bring trouble upon you. Well, well, I'll see about it, Owey. I dare say in a few days I may hear of a farmer on the hills as wants a smart lad, and then I'll speak a word for you."

CHAPTER VI.

THE BOY-MECHANIC MAKES A WATCH, AND THE BOY-BLACKSMITH BREAKS IT.

OWEN for the next day or two could think of little else than his going out to work, and he told all his companions in the village that his father had promised to make a shepherd boy of him. Nor did he forget to communicate the intelligence to old Jack, the donkey, assuring him at the same time that he wouldn't forget him when he was away, for that he would come home once a week with his pockets stored with good things for him. *Then* the old darling should have a regular feast of peppermint drops.

Every evening, too, when Davy returned from work, the boy would anxiously wait to hear whether he had yet found a place for him; and when he went to bed he dreamt of strange things about his shepherd life.

At length, however, the repeated disappoint-

ments drove the thought of going out into the world more and more from the lad's mind, and so made him seek to occupy himself with some fresh work. Accordingly, Owen thought he should like to make a watch for his "Aunties;" but having no idea how a timepiece could go, except by a weight and pendulum, he began to wonder how a watch could be made to keep time in all positions. He wished he had asked Mr. Wilkins the reason of it; *he* could easily have told him.

The boy went to the hatch to listen whether the mill was at work, and catching the sound of the water-wheel, he felt loth to trouble the clothier in the midst of his business. Suddenly, Owen remembered that he had noticed the old sea-captain who lived at the end of the village, and was so fond of his little sister Peggy, had a bunch of seals hanging from his fob; so he thought he'd run up to the house and just ask the gentleman "what o'clock it was," in order that he might get into conversation with him about the matter.

While the boy stood at the door making up his mind to pay the Captain a visit, Mrs. Pugh (his housekeeper) came down to fetch little Peggy, as was her won't at least once a week, saying the old gentleman had got something for her. Glad of the excuse, Owen promised to bring the child, in a few minutes, himself.

As soon as the little girl had been "tidied" and

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invested in a clean pinafore, away the couple trotted up the road. The old Captain, who was sitting out in the sunshine in the front garden, no sooner caught sight of the little thing in her large sun bonnet, than he cried, "Come along toddles! Come along trots! Here's such a beauty thing for her. I bought it a week ago of young what's-his-name, the blacksmith's boy—dear, dear! I shall forget my own name directly—I mean him that lives close to—whose cottage is it on the common—you know, Owen? He caught it in the wood hard by. I gave him a good bit of money, too, for it, I know. Let me see, how much was it I gave? But Mrs. Pugh can say, if I can't. Here! Mrs. Pugh! Mrs. Pugh!"

By this time Owen had jumped his sister up the steps, and as little Peggy came paddling along the gravel walk towards the cottage, the old sailor bent down in his easy chair, and stretching out his trembling hands, held them ready to catch the child. Then having helped her clamber up his knee, he kissed her as though he meant to devour her.

"Has little Peg been a good girl?" inquired the sailor.

"Me a dood doe," answered the child, in her own infantine prattle.

"You haven't been saying 'me sarnt' and 'me boant' any more, I hope," said the old man, holding up his fore finger. "Do you know, Peggy, you

told me yesterday—and yet it couldn't have been yesterday, for I haven't seen you these two or three days past, but it was last time you were here—you loved me 'berry leet,' and that you loved Mrs. Pugh 'berry mut'—after all those 'goodies' I gave you, too. Oh, she's a sly boots, she is. Little puss only said it to make me have a game with her;" and the fond old gentleman hugged the little one to him with increased affection at the remembrance of her tricks.

"Now Peg," continued the Captain, "what do you think I've got for you to-day?"

"Barley tugar," cried the child, holding up both her little fat hands.

"No, it isn't barley tugar, little sweet tooth," answered the old man, as he tickled her in the neck, and made her roll and kick again in his lap with laughter. "Bless her heart!" he added, "I *do* love to hear her chuckle. Of all the sounds in nature, boy," he said, turning to Owen, "there's nothing to an old man, as I am, like a child's laugh—and so you'll think one day, if you are spared. It's so hearty, so truthful, so full of life and enjoyment. Ah! lad," he continued, "what would I give to be like this little thing—full of health, with the blood dancing through one's veins, and a whole life to look forward to, instead of a long mis-spent one to look back upon. It makes us think what fine things we'd do, if we had only our time to come over again.

There's nothing like little children to old people, boy; for they've got what we covet more than anything else—health, and life, and spirits. Not the richest, nor the wisest man in the kingdom do I envy so much as this little blue-eyed doll in my lap. But come, trots, this will never do. We are getting serious and sad, and you come here to make us merry—don't you, little woman? Well, as I was saying, what do you think I've got in the parlour for you, Peg? It isn't 'goodies,' but" (and he whispered the conclusion of the sentence in the child's ear) "a beauty skuggy with a tail as big as the feather at the side of a grenadier's cap. Run and bring the creature here, Owen."

The boy was not a minute gone, and returned, carrying a long cage with an apparatus like a wire barrel at the end of it.

"Oh! booty puss!" cried Peggy, directly she caught sight of the animal.

"Ah! I think he is—a real beauty," echoed the delighted old man; "look at him, he's like a little crop-eared hare with a fox's tail. See how nice and white, too, he is under the belly, Peg, and notice his small black eyes, they're like a couple of pear-pips. Then, look, Peggy, how pink his little paws are underneath, 'Tooc! tooc!' he goes—that's because he can't get in his house. See, now, as I let go the round-about, how he skips and clucks with delight, and he makes the wire barrel spin so

fast, that he looks as if he was inside so much gauze."

"Booty, booty!" exclaimed the little girl, clapping her chubby hands with joy.

"There, Peg, he deserves a nut now, I think," went on the sailor, as he rummaged in his pockets for the remains of the store he kept in them. "You crack it, Owen, for that's more than I can do. Look, how well the cunning fellow knows the sound. Do you see! there's his little bald nose poked through the bars directly. You give it him, Peg; he wont hurt you. Don't be afraid, little one;" and so saying, the old man took hold of the child's wrist and held her hand to the bars, as she shrunk back with fright.

As soon as the squirrel had taken the nut from her fingers, Peggy laughed to see the little thing sit up on its hind legs, and nibble the kernel between his tiny fore paws.

"Isn't he a pretty fellow sitting there with his tail curled up his back like a feather," babbled on the old boy, "and nibbling away the rind, and chucking it from him till it flies about like so much bran. There, now, do you notice, Peg, he's caught sight of you watching him, and the deep little rogue has twisted his tail round his neck, so that you can hardly see his head."

The child chuckled again with delight, as she beheld the squirrel's antics.

"He's finished that nut now," remarked the Captain. "You give him another, Owen, and you'll see he'll go away and hide it under his bed of moss. He's got a rare store there, the rascal, and he's so savage, Peggy, if you attempt to disturb it. He'll scold away then, and almost bark at you like a little toy dog. Look! he's run away into his house with the nut, and there he is digging his nose under the moss," chattered the old man. "Now see how he's scattering the stuff about with his feet. He's doing that to cover himself over, and presently you'll find he'll be quite hidden under it—just as he is every night when he goes to bed. Do you know, Peg, I let him out of his cage every day to have a run about the parlour, and he paddles along round and round the room, with his tail sweeping the ground like a long brush; and when he's tired of that, he scrambles up the chairs and sits atop of the backs of them, looking as impudently as you do, Miss Peg, when you're having a game at 'peep-boh' with me behind the trees in the garden. Then he'll spring on to the mantel-piece, and take a run along there, and when he's tired of that, down he'll jump, and climb up my legs right over my back. Sometimes he'll get on to my skull cap, where he'll sit perched up, with his tail over his head, and eat a bit of apple, if he can only get me to give it him. But his great game, little Peg, is to climb up the what-de-call-em's—the long things at the side of the

window—the—the curtains, to be sure,—and up them he'll go 'tooc-toocing' away, as he jerks himself to the top; and when he gets there, he'll run along the pole above, from one end to the other, for all the world like a tight-rope dancer at a fair, and keep up such a chattering as he goes, that you'd fancy he'd got back into the woods again. Ah! he's a beautiful little fellow, Peggy, and he'll get to love you dearly if you only feed him and take care not to tease him, by disturbing him in his bed, or taking his nuts from him. I got him for you, Peg; so you must give me a big kiss as you call it—one of your very biggest, Peg—and say I'm a dear 'Mitter Jone,' and you love me 'berry mut.' No! that isn't half a one, Miss," the old dotard cried, as the little thing scrambled up and stood on his knee, while she threw her podgy little arms about his neck, and squeezed him to her. "'More!' as you say for the sugar plums, Peg. Ah, that's better! but I must have another still;" and as the sailor said so, he threw her in his lap and kissed the child under her chin till he made her chuckle again with the tickling.

By this time the old man had become tired with the pranks he had been playing with the child; so when Mrs. Pugh came out to advise him to go in doors, as it was getting chilly now that the sun was off the cottage, he bade his housekeeper "take Peg and her squirrel into the kitchen, and give

the pet a good plate of that raspberry tart they'd had at dinner." He told the dame also to bring some fruit out of the garden for Owen, and to put the currant wine on the table.

As soon as the housekeeper had moved the arm chair into the parlour and wheeled it up to the window, the white-haired old man shuffled into the room, leaning upon Owen's shoulder.

The boy fidgeted about the parlour for some little time, looking at the various shells under the side-board, and the model of a ship under the glass case that stood on the side-table, with the little earthen images of Indian figures set round it. Then he turned to the Chinese fans and pictures against the wall, and glanced at the hookah, that stood on one of the shelves of the three-cornered cupboard, with the old china cups and saucers showing above it. There was a walking-stick, too, made out of a shark's back-bone, hanging over the looking-glass, and a dusty old stuffed albatross, standing near the window.

But the boy was too intent upon the purport of his visit to pay much attention to any of the curiosities, and was, even while he pretended to be viewing them, summoning up courage to ask the old captain to let him have a look at his watch. Presently the lad said, half to himself, "I wonder what the time is?"

"Oh, it's not late, boy," answered the veteran, pulling his watch out of his fob; "it's only ten minutes past three, by my watch, here."

At the word the boy turned towards the window, and observing the timepiece in the sailor's hand, requested the old man to allow him to look at it.

"Oh, I understand," exclaimed the Captain, "you want to have a peep at the works. Well, I was just the same at your age, and thought the inside of a watch the prettiest sight in the world." So saying, he pressed the spring, and lifting up the dial, took off the brass cap that covered the wheels of the little timepiece.

"How beautiful it is," cried Owen, as he gazed with wonder into the works, "to see the little bright wheels twirl round, and this one here, swing backwards and forwards. I suppose that's the same as a pendulum in a clock, sir?"

"Yes," returned the old man; "but what do you know about pendulums, youngster?"

"I know," replied Owen, sharply, "that a pendulum of three feet and a quarter will swing once every second."

"Hey-day!" cried the sailor, "you know a good deal, then, for a lad of your age."

Encouraged by the approbation, Owen told the Captain that he had just made a clock, and now wanted to understand how it was a watch could go without a weight to it.

"Well, boy," answered the Captain, pointing to the works of his own timepiece, "that brass barrel, you observe there, with the little steel chain round it, is what is called the spring-box, and it's that which makes the wheels revolve."

The little fellow then asked what it was that made the box itself go round.

"Why, there's a steel spring within it," answered the old sailor; "and, as that uncoils, it forces the box to turn on its axle."

But Owen had never seen any other spring than that to his own bird-cage, so he asked how a spring inside a box could cause the box to go round often enough to wind all the chain upon it?

The old man answered that the spring was long and thin, and that one end was fastened to the axle on which the box turned, and the other to the inside of the box itself, adding, that the axle was fixed, while the box was set loose upon it.

The boy bit his lip, ashamed to say he did not thoroughly understand the matter yet.

"I see," said the Captain, "you can't make it out. Well, my lad, take a long narrow piece of whalebone," he proceeded; "hold one end of it fast by your thumb, and wind it round your fore finger, you will then find that the whalebone will try to unwind itself; and if you fix the other end of it to the inside of a flat ring, like the rim of a good-sized pill-box, and leave the whalebone to itself, it will

turn the rim round and round, and wind up a thread tied to the outside."

The lad thanked the Captain, and said, now he understood it perfectly.

"Not quite so fast, youngster," exclaimed the sailor; "for you see, when a spring is put in the place of a weight to drive the wheel, there's a great difference in the action of the two. The force of the weight is the same all along, but with the spring it's much greater at the beginning than it is at the end, for the more and more it unwinds itself the weaker and weaker it becomes."

"I see," said Owen, thoughtfully, "and how can that be got over, sir?"

"Why, that's done, my little man," replied the Captain, "by what's termed a 'fusee.'"

"What's that, if you please, sir?" inquired the boy.

"Well, a fusee," responded the old sailor, "is nothing more than a conical-shaped barrel; that is to say, it's a barrel made in the form of a small sugar-loaf, bigger at the bottom than it is at the top, and with a long spiral groove cut round it from one end of it to the other. You know a peg-top, of course, youngster? Well, the small end of that with the groove round it where the string is wound, is a perfect fusee. The watch is wound up by turning round the axle of the fusee, and then the chain is drawn from off the spring-box, and twisted round and round

the fusee barrel, in the same manner as the string is wound round your peg-top. But as the watch goes the spring uncoils itself, and so turns the box round the reverse way. By this means the chain is wound off the fusee on to the box again, and in such a manner that at first, when the power of the spring is the *strongest*, it's pulling at the *small* end of the fusee barrel, while at last, when the power of the spring is the *weakest*, it pulls at the *thick* end. Thus the power is applied farther from the centre of the fusee axle, just in proportion as the spring gets weaker, and therefore the force is rendered equal and regular throughout."

"Thank you, Captain Jones, I know what you mean very well," said Owen, "for it's the same as the wheel and axle."

"Very well said, lad," responded the sailor; "so it is. You know about wheels and axles, too, do you? Well, then, master Owen, you know a great deal more than I did at double your age, for I was a sad idle young scape-grace, and that's why I was sent to sea—between you and me and the post. I dare say, too, if Captain Chapman, of the Honourable Company's Service, that I first sailed with, hadn't kept me 'taut' up to the mark, and made all the young gentlemen—that's what they call the middies—study about chronometers and such like, I should have known no more about the inside of a watch than I do of the inside of a Punch and Judy

show. I've only told you though, lad, how the main-spring in a watch is made to do the duty of a weight in a clock. But a watch, you know, as it has to go in all positions, can't have a pendulum dangling from it. So how do you think that's got over? Why, instead of a pendulum, youngster, there's a balance, or fly wheel, worked by the escapement, and this has a small spring to it, because it's been discovered that the vibrations of a spring, whether large or small, (like those of a pendulum,) take place in equal times, and the consequence is, the balance-spring in the watch is made to serve as the pendulum, even as the main-spring acts as the weight. There, now you know all about the watch, for the wheel-work is the same as that in a clock."

"Oh! thank you, sir," replied the boy.

"Egad, you seem, my little man," laughed the Captain, "to take a deal more interest in the matter than I ever did. I've been mast-headed over and over again before they could get that stowed into my noddle. If I'd have learned it only yesterday instead of sixty years ago, I should have forgotten it all by this time; but I was much fonder of catching sharks than studying navigation when I first went to sea, and that was on the 30th of June, 1791. I was telling young what's-his-name—that I bought the squirrel of—I mean young—who-do you-call-him, of the forge yonder?"

"Jarman?" suggested Owen.

"Yes! that's he," said the old man. "What a boy that is for 'yarns'! Why, it was only last—no, it couldn't have been Wednesday, because somebody was here that day—who *was* it I had with me then?—Tut! tut! it wasn't the doctor from Builth, because he came last Sunday. Let me see, though, *did* doctor come on Sunday? To be sure he didn't, for Mrs. Pugh had her friend to tea with her that afternoon—her niece, or her cousin, or something of that sort. She told me a long story about how she was left an orphan by somebody or other, though for the life of me I can't recollect a word of it now. But what was I saying?—let me see—let me see," mumbled the old captain, as he put his shrivelled veiny hand before his eyes, and clasped his forehead in the bewilderment of his memory.

"You were telling me, sir, about when you first went to sea," said Owen.

"Ah!" cried the old sailor, waking up, "I can remember that, well enough, it was a month after I left Bristol Grammar School, and Mr. Peace, one of my father's clerks, who had been to sea himself, was sent with me down to Gravesend; and I recollect he took me to the King George's Head there, and gave me a good feast of cherry and currant pie, saying, 'Well, youngster, you'll be a long time before you come athwart cherry and currant pie again; so you had better stow away in your hold now as

much as you can carry.' And sure enough I *did*. Why, when I'd done, the gilt buttons on my buff kerseymere waistcoat—for I was in full uniform—were ready to start out by the roots."

"And did you like being at sea, sir?" inquired Owen.

"Like it!" echoed the old captain, "not at all at first, lad. How would *you* like to live for four long months—we didn't make land, my first voyage, for fifteen weeks, excepting just a glimpse we got of the Cape on rounding it; we ran short of provisions, too, towards the end of the voyage, and had to send the men out in boats to catch turtle. But where was I!—dear, dear, where was I!—I can't keep a thing in my head for two minutes together. I'm sure the other day I was talking to Squire Williams, of Llangoed—no it isn't Squire Williams that lives at Llangoed, it's Squire, Squire, Squire—" muttered the Captain, half to himself, as he beat a tattoo with his fingers on his forehead.

"Macnamara?" hinted the boy.

"You're right lad," nodded the old man. "Well, I wanted to tell him something I'd read in the newspaper that I knew would interest him greatly—it was either about fishing or shooting, or a railway accident, or a marriage of somebody or other; but for the life of me, my dear boy, when I began to out with it, I couldn't remember where I'd seen it,

or what on earth it was about. It was so strange, too, for I'd read it only that morning—that is to say, it must have been the evening before, because I never get the Hereford—Hereford—Times,—no, it isn't the Times I take, either,—but we won't mind about the name; I know I never get the paper till the Wednesday, or else it's the Thursday, or the Friday afternoon—I'm sure I can't say which just now. Still, that's not what I was saying. Where did I leave off, lad?"

"If you please, sir," replied Owen, glad of the opportunity to bring the wandering old man back to his story, "you were asking me how I should like to live for four months on something; but you didn't say what."

"Oh! I recollect," cried the veteran, "I was saying how would you like to live for fifteen long weeks, as we 'middies' did, when I first went to sea, on maggoty biscuits, and putrid water and 'junk,'—that's hard salt beef, lad; so hard, too, that you could cut it into cricket-balls, and so salt, it's like eating brine itself. Ah, many a time I've been mad with thirst from the heat of the day, for the sun is right over your head in those parts, and makes the pitch in the seams of the deck as soft as treacle. We were only allowed a pint of water, do you see—over and above our grog and our tea—and that was as black and filthy as if

it had come out of a cesspool; why, I used to strain it through the corner of my handkerchief as I drank it from the tin 'tots.' The water rots, youngster, a little while after you get to sea; and sometimes when I've been down in the hold to see it served out to the men, I've been nearly stifled with the stench of it, as it was pumped out of the casks. It's true, we 'young gentlemen' had a mess of our own, and had laid in a store of sugar and tea, and hams, and potted meats and soups, and what not. But bless you, these were all stowed away in the lockers round the berth,—that's a place about as big as four sea-chests, that six of us middies had to live in, and with a scuttle, or window to it, as you'd call it, about as big as the lid of a work-box,—and the very first sea we shipped—Oh! I remember it as well as I do going to the India House to receive my first pay. We were at tea, between the dog-watches, as they're called, and I was a-sitting right under the scuttle, with the cups and saucers set out before me on the little table that was slung from the beams above, and *in* the waves poured, for all the world like what you might fancy would be the case if the mill dam yonder were taken away suddenly, and all the water behind it let loose at once. Well, I fancied—green-horn as I was then—that we were going straight to the bottom; so I struck out swimming away for dear life, and each stroke I made I sent the crockery flying. When the torrent

had ceased there *was* a pretty state of things. Our cask of sugar, that stood in one corner, was salt-water treacle; our packets of tea in the lockers were all pappy; our fresh Lemann's biscuits, too, were, like so much sop; and there was my best uniform hat, with its grand cockade, chock full of sea-water, and as soft and limp as a bit of hard-bake in hot weather."

This was too much for Owen's gravity, and he laughed outright at the misadventure, the Captain joining in with a heartiness that made the tears trickle from his eyes. "That young blacksmith wants to be off to sea," proceeded the garrulous old man, "but he little knows what a sailor's life is. Why, I've seen a ship full of men thinned with a disease breaking out in it like a hive of bees stifled with sulphur; I've known many a man full of life and health at mid-day, and heard the bell toll his death before sun-down; and the next morning I've been summoned on deck to see him tossed from the gratings at the gangway into the sea. Again and again, too, I've been roused from my sleep in the night by the cry of a man overboard ringing in my ears, and rushed upon deck just in time to see the boats lowered, and six anxious shipmates pulling away in the darkness, guided only by the faint blue light of the buoy that some kind hand had cut away, the moment the cry was raised. I've watched that boat, as the ship, with all the sails aback, lay still,

hunt and hunt about in the wide waste of waters—now turning this way and then that, according as the crew fancied they heard the poor fellow's cry for help and life. And at last I've seen them come back with drooping heads and sad faces to tell that another companion was gone. I can remember these things, lad, well enough," continued the old man, sadly, "and often, as I sit out at the doorway in the sun, I see many a scene of that time that I would willingly forget."

"Hush! I thought I heard little sister crying," exclaimed Owen, suddenly starting to his feet.

The old man listened for a minute, and then burst out—"Yes, it *is* Peg, sure enough. Run and bring her here. You're quicker at moving than I am, boy. Poor little dear, whatever is the matter?"

In a few minutes Owen returned with Mrs. Pugh, carrying the child screaming in her arms.

"Give her to me!" cried the Captain, stretching out his hands to receive her.

"She's only fallen down, sir," said the housekeeper, "and is more frighted than hurt."

"*Only* fallen down!" shouted the sailor, angrily; "you should have taken better care of the little thing, then." And he kissed and hugged the child fondly to his bosom.

Mrs. Pugh turned upon her heels, muttering as she tossed her chin in the air, and left the room,

"You're always having a pack of young brats here, you are."

"There, there, little Peggy, don't'ee cry," said the tender-hearted old man; "let Mitter Jone kiss it and make it well. It will soon be all right again now. Bless its heart, no one shall hurt it while Mitter Jone is here. Come, brother will carry her squirrel for her, and she'll go home prettily, like a darling as she is. Oh! and here's your old doll, Peg, you left behind you last time;" and, as he said so, the sailor beckoned to Owen to go to the drawer of the sideboard, whence the boy took a square wooden stump, with a round head rudely cut on top of it.

"Now she's got her own baby—and a beauty it is, I'm sure," said the sailor, winking and laughing at Owen, "she'll go back like a good little pet, and come and see her dear Mitter Jone again, directly. So give us a good kiss, Peg, and say 'tata.'"

Then the old sailor having hugged the child once more fondly to him, sat shaking his hand at the window as he watched the little couple go down the walk. "There she goes cuddling that lump of wood, and quite happy now," muttered the veteran to himself. "Well, we must have something to love, young or old."

When Owen returned home with his little sister

Peggy, he was intent upon making the watch he wished to present to his Aunties at the parsonage.

It took the lad no little time to construct one with small wooden wheels and a spring of whalebone—for that was the only elastic material he had at hand. What was worse than all, however, he found on putting the parts together, that he could not get the watch to go when the balance was on, for the fine teeth of the wheels were too weak to bear a force sufficient to drive the additional weight, although the wheels would run fast enough when the balance was taken off.

This was a great disappointment to the boy; and as he saw no remedy for the defect—for he was unable to construct the wheels of any stronger substance—he made up his mind merely to show the watch to his Aunties, and tell them that, when he was a better workman, he would make another for them which should work properly.

Accordingly, Owen enclosed the wooden works in a rude case that he formed out of an old tin mug, little bigger than a breakfast cup, and then he started towards the parson's, anxious to let the clergyman and his girls see that he had not forgotten their kindness to him.

It was Lucy's week then to attend to the duties of the house, and the girl was busy with her gloves on, polishing the tins and candlesticks that lay con-

fusedly on the table before her, when Owen entered the cottage.

Lucy, who had been too intent on her work to hear the gate swing, gave a start as she saw the boy standing in front of the table. Then hastily pulling the gloves from her hands, she jumped the little fellow on to her knee in order to kiss him.

"Take care, Auntie Lucy," cried Owen, as he guarded the watch which he had tied in the handkerchief he held in his hand, "or you'll break what I've got to show you."

"Oh! let me see it, Robin dear," exclaimed the girl, as she set the boy carefully on the ground; "whatever have you been doing now?"

"But where's Auntie Betty and Mr. Wynn?" inquired the boy, looking round the kitchen.

"Betty's gone to take some work home," answered Lucy, "and you know it's the day for her to leave the copy-books at the turnpike for the scholars at our Sunday school, so that when the carters go by, they can call for them there, and carry them back to the farms. And father, Owey, is in the parlour," added the girl, pointing to the little room adjoining the kitchen, "preparing his discourse for to-morrow, so we mustn't talk loud. Auntie Betty has been gone some time, so I shouldn't wonder but we shall have her back soon. But you may as well let me see now what you've got, and not keep me wondering here till Betty returns."

"Well, Auntie, do you know," said Owen, as he proceeded to untie the handkerchief, "I wanted to make a watch for you and Betty; and when I'd cut out all the wheels, I found that it wouldn't work with the balance on—wasn't it a pity?"

"Oh! you dear fellow, to think of us! but never mind, Robin, we shall prize it all the same," said Lucy.

"No, but Auntie, it's of no use as it is," replied the lad, "so I only brought it up to show you what I'd done; and I thought Mr. Wynn would be pleased to see it, for he'd then know that I hadn't forgotten what he'd read to me. But Auntie, I mean to make you a grand one, by and bye, when I can work better."

"Do let me see this one, Rob," asked the eager girl, as she helped to unfasten the knot that Owen was teasing. "Oh, you clever little dear, you," she cried, as she caught sight of the card-board face. "And did you do all that yourself?"

"Yes, that I did," said the boy, with pride; "and look here, Auntie, at the works. I cut them all out with a penknife, and made the spring out of one of the ribs of an old umbrella. I was obliged to put it in this old tin case, because I couldn't get anything else that would do for it. I wish it would have worked with the balance on, though; because it might have been of some use to you, and now it's only an ugly-looking toy."

"I'm sure it's very, very pretty," answered Lucy; "and we shall keep it, and guard it for your sake. I'd rather have it as it is, than the grandest gold one that could be bought."

"No, would you, Lucy?" inquired the delighted boy.

"Yes, that I would, because you made it, Robin, dear," returned the girl; and she kissed Owen again and again. "Father will come in when he's done his work, and you shall show it him," added Lucy; "I'm sure he'll be very pleased with it, and Betty too."

At this moment the gate was heard to swing back, and Owen ran to the door with his watch in his hand, saying, "That's Auntie Betty, I dare say."

No sooner had he reached the porch, than John Jarman, his face crimson with heat, rushed past him. As he did so, the watch was knocked from Owen's hand, and falling at the young blacksmith's feet, was in a moment crunched beneath the heavy boots of the boy.

CHAPTER VII.

HOW THE PARSON'S DAUGHTERS TURNED THE HEART OF THE RUNAWAY.

Owen shrieked as he saw his handiwork crushed on the kitchen stones. He stood for a moment as if paralysed by the disaster, and then running towards Lucy, threw himself on her neck, and burst into tears.

"What's happened to my boy?" cried the frightened girl, as her father, surprised by the noise, hurried from his room.

"Look there, Auntie," sobbed the little fellow, pointing to the flattened case as it lay on the ground; "and Mr. Wynn hadn't seen it, nor Auntie Betty either. I wouldn't have cared so much after that. I *do* think he did it on purpose—that I do;" and the boy having given an angry glance at Jarman, fell to sobbing again as if his heart would break.

"What does it all mean, Lucy?" inquired the astonished minister.

The girl explained to her father the cause of

Owen's grief, telling him how the little fellow had made a watch for them, and was anxious to let him see how well he had profited by his lesson when he was last with them.

Mr. Wynn took the boy from Lucy's side, and lifted him on his knee, as he turned to young Jarman, saying, "What brings you here, sir, in such haste, that you must rush heedlessly into the house? You're wrong, Owen lad," he added, "in thinking Jarman did it on purpose, though want of care is sometimes as culpable as want of feeling."

The blacksmith boy was not a little disconcerted at the presence of the minister; but he was in no humour to bear rebuke, so he answered savagely, "You'd have run as I did, if you'd a father like I've got; but I wont stand it any longer, I've made up my mind. I'll be off, and he may get some one else to do his work; then he'll be obliged to pay those who slave for him something else than blows for what they do. Father came home drunk last night, and dragged me out of bed, and thrashed me round the room as I was—for what I don't know. I'd done nothing that I remember, but use his fishing-rod; and this morning, because I hadn't lighted the forge fire, he struck me over the arm with one of the irons. Look here," he said, pulling up his shirt sleeve, "it's all black and swollen, and pains me dreadful when I move it. I don't care if he *is* my father, I wont stand it from any one; I came here to ask one

of the Miss Wynns to go down and fetch my clothes for me, and to tell mother I was going away to Bristol to get aboard a ship, and I'd write to her soon. It a'n't her fault, poor thing! She can't keep him off me, do what she will. If I'd been a little bigger this morning, I'd have,"—and the boy crunched his teeth, and clenched his fist revengefully.

"Silence, sir!" shouted the minister. "How dare you give vent to such thoughts in my house? If we are to shelter you from your father's rage, you must have a different spirit from this."

At these words, Lucy crossed the room towards her parent, and letting her hand fall on his shoulder, whispered, "But, father, think how sadly the boy has been ill-treated."

"My girl," returned the minister, gently, "it's only in suffering that true nobility of nature can be shown, for if ferocity begets ferocity, the persecuted become as brutal as their persecutors. So far from countenancing this lad in quitting his parent's roof, I shall consider it my duty to take him back to-morrow."

The words were no sooner uttered, than the young blacksmith turned on his heel, and with a dogged jerk of his head, disappeared from the place.

"He's gone!" cried Lucy. "Run you after him, Owen, and bring him back."

"Nay, nay," replied the minister, "stay you here,

lad! The boy is in too dangerous a humour for you to be trusted with him."

"See, father," said Lucy, "you've frightened him from us. You, yourself, say we should be kind to all, and more especially to those in affliction; and yet when that poor boy seeks shelter from his father's fury, you turn him from you with harsh words."

"He uttered threats against his parent, child, in my presence," responded Mr. Wynn, "and it was my duty to rebuke him for so doing."

"Yes, father, but you were harsher than I ever knew you yet, and what John Jarman wanted was kindness, surely, in such a mood as his."

"Well, perhaps you're right, my gentle-hearted girl," said the minister; "we men, you see, are too quick and hasty, and know little how to make peace like you."

Lucy kissed his forehead, as she said, "Let me go after him, and bring him back, father. I'll promise you I'll not teach him to rebel against his parent."

"God bless you, child," cried the old man; "go and do as you will."

The anxious girl hastily put on her bonnet, and was hurrying from the door, when Betty came through the orchard gate.

"Oh! Betty, Betty!" whispered Lucy, as she ran up to her sister, "there's been such a scene since you've been away. Young Jarman's run away from home, and father wouldn't shelter him."

"I know all about it," answered the girl, in the same under tone. "I met the boy up the lane, as I came along, and he told me everything. He's in Gwillim's meadow, behind the haystack. I bade him wait there till I'd spoken to father."

"I'll go and bring him back with me," said Lucy, "and you run in, and give father his tea in the parlour. He doesn't know how to deal with boys like John Jarman. You'll find little Robin in doors. Poor little fellow! *he's* nearly broken-hearted, too."

"Yes, yes, I know," answered Betty, quickly; "John Jarman told me he trod on the watch Owen had made for us, and *that* I dare say, Lucy, made father more angry than he would have been."

"Did Jarman show you his arm?" inquired Lucy. "What a shocking state it's in!"

"Yes, dear," replied Betty, "it quite made me shudder, poor boy! There you run to him, Lucy, and I'll get something ready to bathe it with. We can easily make him up a bed on the sofa for to-night."

Lucy trotted off delighted with her mission, while Betty entered the cottage, and proceeded to carry out her sister's injunctions.

Betty was busy in the little parlour, making her father's tea, when her sister returned with the runaway. As Lucy entered, she whispered to the

boy to do as she had told him. "Come, John," she said, in an under tone to the lad, who hung back moodily by the door, "never be ashamed of doing what's right; go and tell the little fellow you are sorry you broke his watch;" and as she said this, she led the sullen boy to Owen, who was sitting by the chimney corner, still lamenting his loss.

The blacksmith's boy muttered sulkily, "I didn't mean to break your watch, Owen."

Owen Evans looked up, and held out his hand, saying, "Let's make it up, John! I didn't know you had been beaten, when I said you did it on purpose. But you're not *really* going to run away, are you?" anxiously asked the boy.

"No, no!" said Lucy, "he'll go home with me like a good fellow in the morning, and I'll see his father, then, and talk to him."

"I'm sure I wont," growled the boy. "I've made up my mind, and nothing shan't stop me. I've got the money Captain Jones gave me for the squirrel; besides, there's an aunt of mine lives at Aberga'ny, and she'll help me on the road a bit, I know. She was very good to me once afore, when I was going to cut away to the iron works—and I should ha' done it too, if mother hadn't come over after me and told me as how father had promised to treat me different. But I a'n't quite so little as I was then, and I wont stand being knocked about any longer—that I wont."

"Well, well, John," interrupted Lucy, "we'll talk of that another time. We'll have a nice tea now, and sleep over the matter; then we'll see how it looks in the morning. Come, John, you help me set the things, for Betty I'm sure must be tired, and want something after her walk."

"And can't I do something, Auntie?" inquired Owen, jumping from his chair.

"Oh yes," replied Lucy; "you shall toast the cakes while John puts the tray. Do you know," continued the girl, as she handed Jarman the cups, "I think our mare wants shoeing again, John."

"I shouldn't wonder," returned the blacksmith, "for it's a good nine months since she was down at the forge. I remember I caught that owl of mine in the dingle the night I brought her home."

"You helped to shoe her, didn't you, John?" inquired Lucy, as she put the cake on the toasting fork for Owen.

"Yes," answered the boy; "I made one of her shoes, and that was the first I ever made all by myself."

"Do you know, John," said Lucy, delighted to lead the boy's thoughts into another channel, "I've often fancied how strange it will be when you are master of the forge at Llanvach, and we have to send Jessie to you to be shod—*you*, a little fellow I have nursed on my knee. Wouldn't you like to be able to work in iron, Owen?"

"Ah! *that* I should!" replied the boy. "If I could only have worked in metal, Auntie, the wheels of my watch would have been strong enough to move the balance when I'd put it together."

"I do think," added the girl, "metal work is one of the most wonderful things in the world. I'm sure I can't tell how you do it, John. Why when I've been out with father, and he has taken up a bit of rock, and has told me that was the stone the iron was got from, I've wondered over and over again how it was possible to make a horse-shoe, or anything else out of that, and how clever you people must be who do it."

Lucy noticed John Jarman smile with pleasure at what she said, and was about to proceed, when Owen inquired—

"But do they, Auntie, get all the iron things out of stone?"

"To be sure they do," responded the blacksmith boy, turning round sharply to the other. "Where do you think the iron comes from? It doesn't grow, silly. When I have been over to the Works at Merthyr with father, I've seen them smelting it many a time, and a very pretty sight it is, too."

"Can't you tell us how they do it, John?" asked Lucy, pleased to find the boy growing interested in the subject; and as Betty entered the kitchen, the girl made signs to her sister not to interrupt the conversation.

"Father's told me all about it often," continued young Jarman, as they sat at the tea-table. "You see, Miss Wynn, he says that the metals are seldom found pure in the earth, but mostly always mixed with something else, and then they call them '*ores.*' The stone the iron's got from in this country, doesn't look to have a bit of iron in it; because, as father says, it's all rusted like, and mixed up with earth; and iron-rust, you know, a'n't anything like iron, though it's made out of it to be sure. Well, as father says, if iron-rust is made out of iron, why of course, iron can be made out of iron-rust."

"Yes, John," chimed in Betty, "I should think so; but how to do it I'm sure I should never be able to tell."

"Well, you see, that's what they call smelting," answered the boy, not a little proud of what he knew of the matter. "They put something into the furnace to serve as a flux for the earth."

"What in the world's *that*, John?" asked both the girls, anxious to let the lad see he knew so much more than they did.

At this the blacksmith's boy laughed outright. "Why, that's something," he went on, "that serves to melt the earth that the iron's mixed with in the stone, and so to separate the metal from it. You see, it's limestone they generally use for this purpose, because lime makes what is called a 'slag' with the earth; father says the slag is a kind of glass, that

melts with a great heat. Well, as the slag begins to run, the iron of course comes from it. But, you know, I told you it wasn't pure iron, but only iron-rust that was in the stone; so they put a lot of coke into the furnace, as well as the limestone, and that serves at the same time to unrust the iron; for father says the coke when red-hot, takes away from the iron just what the iron got when rusting; and so, you understand, the iron is left behind, pure. Then it melts like the slag, but as it's a good deal heavier it tumbles down to the bottom of the furnace, and is there let run out into moulds. Now, you remember, I told you the iron-stone was made up of earth, and iron-rust. Well, the lime, you see, melts out the earth, and the coke unrusts the iron, and so, you know, the pure iron must be left behind. You must excuse me, Miss Wynn, if it a'n't very plain, for I'm not much of a scholard, you see.

"Oh, I'm sure you've explained it very well indeed, John," replied Lucy. "I've often wondered how it was done, and now I shall know all about it."

"It was Tubal Cain, John, who was the first worker in metals," remarked Betty.

"Yes," chimed in Lucy, "and the Greeks thought it such a wonderful thing to do, that they positively worshipped an old blacksmith of the name of Vulcan."

"*Did* they, though?" said the boy, laughing. "Well, they don't think so much of the trade now-a-days."

Betty replied, "But every sensible person, I'm sure, John, must know how much we are indebted to such as you. Father says it is the smith who makes all the tools, and tools do all the work in the world. I've often heard him remark, that as the hand was the most useful of all our organs, the tool—which was another hand to the workman—was the most useful of all instruments."

"Yes," answered Jarman, "it's a handy business enough. I've often, myself, thought when the plough-shares and the sickles has come to the forge to be mended, how would people be able to plough and reap without us?"

"Yet, John," said Betty, "you think of giving up such a noble business as this to go risking your life at sea?"

"Ah," exclaimed Owen, "I only wish, John Jarman, you'd heard Captain Jones tell me what he did about a sailor's hardships. I'm sure you wouldn't have liked it then."

"The old captain has told me a lot of things that way," answered the young blacksmith, "but he only does it to set me against the sea."

"Why should you say that, John?" asked Lucy; "I'm sure the gentleman wouldn't tell you what was untrue; and I can't understand why you should

prefer such a business to your own. Why, a sailor's only a carrier, at best; he can't *make* a thing like you."

"That's true enough," said the boy; "but it must be so pleasant to be on the water all your time, and to go to foreign lands, and see what the world is like in other parts."

"I'm sure I shouldn't like the water at all," added Betty, shuddering, "with the chance of being shipwrecked every minute, too. And only think, John, if you were to go, the state your poor mother would be in all the while you were away. You're her only child, remember, and if she was to lose you, I *do* think it would be the death of her. I've heard you yourself say, too, that your father's very kind to you when he is sober."

"Yes, so he is," continued the lad; "but he's over at 'the public' half his time now, and mother gets to fret dreadful about him, for the people complains as the work's neglected, and threatens to take it to Bronllys, if they can't have it done sooner."

"And yet you, John," said Lucy, "would run away and leave her at such a time. Now just think, lad, if your father gets to neglect his work more and more for the drink, and the business is broken up, what's to become of your poor mother then? Why, there'll be nothing but the workhouse for her, and how would you like *that*?"

"Why, I couldn't bear it," exclaimed the abashed boy, as he drooped his head at the thought.

"No, I know you couldn't, John," said Betty, kindly; "you've too fine a spirit for that. I'm sure you'd rather do anything, and rather bear with anything, than let her come to the parish in her old age."

"Yes, so I would," answered the blacksmith's boy, "but—but—"

"No buts, John," said Lucy; "surely a blow or two isn't much to put up with for her sake—after all her care of you. If I'd a mother, no cruelty could ever make me forget my duty to her. And I'm satisfied, John, that you yourself would work night and day for yours."

"So I would," he added.

"Well, then, think," continued the girl, "if you stay with her what a comfort you can be to her in all her trouble. Then, if your father neglects the business you can mind it, and what an honour it will be to you, a mere boy, to keep the home together; *that* would repay you well for the blows you've had to bear. But if you run away and leave your poor mother, now that you are getting to an age to help her, take my word for it, John, you'd *never, never* forgive yourself."

At this Betty rose from her seat, and going over to the boy, put her arm round his neck as she said, "Come, John, you wont go away, will you?"

The young blacksmith hid his face in his hands, and sobbing aloud, cried, "No! I wont—I wont go. Father may knock me about as he likes, but I'll bear it all for her, though it *is* hard to put up with at the time."

"Yes, so it is, good fellow," exclaimed, Betty, patting him on the back, "and so much the nobler of you, John, to bear it. If your father forgets what is due to you as his son, at least do you let him see that you are not unmindful of what is due to your parents; and depend upon it, if you bear his cruelty patiently, he'll see how wrong it is much sooner than if you rebel against him."

"Father! father!" whispered Lucy, as she ran into the adjoining room, "John Jarman has promised to go back home to-morrow."

"God bless you for it," returned the clergyman, as he looked up from the book before him.

"He's a good boy at heart, I'm sure," continued the girl, "though he has a spirit of his own."

"I dare say, my child, he's like the best of us, a strange compound of good and evil," said the minister, "and no one knows so well as my girls how to bring out the one and subdue the other. You see, Lue, while I'm busy here preaching kindness, you're practising it. You're better ministers of peace, girls, than your father is."

Mr. Wynn rose from his seat, and entering the kitchen, went towards the young blacksmith. "I'm

glad to hear, boy," said he, as he took him kindly by the hand, "that the prodigal is to return on the morrow. Filial ingratitude, my lad, is the worst of all kinds of ingratitude, for it puts an end to the most sacred of the social ties. The birds and the beasts leave their parents immediately they can shift for themselves; for such is the care of life where there is no foresight, and no store for the future, that each has enough to do to struggle for itself in the world. Moreover, few of these live to become old and helpless, and so to need the care of their offspring in after-life, as we do. But man, you see, Jarman, is twice a child; and they who have toiled to foster their children in their helplessness, come, in the round of nature, if they be spared, themselves to need the like fostering care from the hands of those they've reared. For as soon as the young are getting to help themselves, the Almighty has ordained that the old should mostly be losing the power to do so. And as He has made it the duty of the parent to protect the child in the weakness of infancy, so has He made it the duty of the child to protect the parent in the like weakness of old age. Why not strive, lad, to be like Owen here? *His* greatest ambition is to be able to assist his parent; and I'm sure when his father has taught him the means of earning a livelihood, he'll be the last to think of running away, and leaving him, just at a time, too,

when his labour is getting to be of some service to the old man. *He* thinks how his father has to work for him now, and longs, like a grateful boy, to work for his father in return."

As Owen heard these words, he could not help thinking of the vow he had made, that he would so excel the blacksmith's boy, that he should hear his praises wherever he went. But the moment after, the generous lad felt it unworthy of him to triumph over the other at such a moment, and went towards Mr. Wynn, saying: "But John, sir, is returning, so that he may work for his parents too."

"I'm glad to hear it," said the minister. "But come, we'll say no more about the matter; John and I will pass the evening talking over pleasanter things, and in the morning Lucy shall walk with him down to his father's, and get Mr. Jarman to promise to treat the boy more kindly for the future."

"Now, little Robin," said Betty, laughing, "it's time for you to think of returning to your nest. Do you see the sky how red it is, yonder? It's as much as you'll do now to get home before dark."

As Owen was about to leave, young Jarman followed outside the door, saying, "Just call at mother's, will you, Owen, as you go back, and tell her I'm up here, or else she'll be getting frightened about me."

"Oh, yes, John, I'll be sure to let her know," re-

plied Owen; "and shall I say you're coming home to-morrow?"

"Yes, you may if you like," responded the young blacksmith. Then as the little fellow was pulling back the gate, Jarman ran after him once more, and laying his hand on his shoulder, said: "I didn't mean to hit your donkey, Owen, with that bit of iron the day you came to the forge. I should have told you so before, only you chose to quarrel about it. We'll make it up now, wont we, eh?"

Owen pressed Jarman's hand affectionately, saying, "We're friends now, John, and wont fall out again;" and hurried off, thinking how much happier he felt now that he was at peace with his former companion.

CHAPTER VIII.

THE BOY HAS A TALK WITH THE OLD SAILOR ABOUT THE "LOG."

EARLY in the next week, to Owen's great delight, Mrs. Pugh came to the cottage to say she had been sent to fetch him, to spend that afternoon with the Captain.

On returning with the housekeeper, Owen found the sailor by himself in the little parlour, and the boy had no sooner entered the room, than the Captain cried—"How about the watch, youngster? have you got it altogether ship-shape yet?" whereupon Owen proceeded to recount to the old man how he had made it, and how, to his great annoyance, it had been broken shortly afterwards.

"Well, never mind," said the sailor, at the conclusion of the tale; "I sent for you this afternoon, lad, to make you a present of a real silver one."

Owen was so startled at the unexpected news, that he could hardly stammer out his thanks.

"It's the first one," answered the sailor, "I ever

had given to me, and that was when I passed my examination for fourth officer in the East India Merchant Service. I used to call it the 'Tea Service' in my young days, ha! ha! I was a sad wicked dog when I was a middy, to be sure — always rigging out bits of wax candle on a hook with feathers stuck at the side of 'em, to catch the boneta—that's a large fish, and very tidy eating, too, I can tell you, when one hasn't had a bit of fresh food for months. You see, we suspend the hook to the end of the dolphin striker—which is a wooden spar hanging down under the bow-sprit—so that when the ship pitches, the candle and the feathers just dip into the water, and then, as the ship rises again, and cuts through the sea, they skim through the air and seem for all the world like one of the flying-fish that the boneta chases in those parts. Flying-fish, youngster, you must know, can only keep above water as long as their wings—which are only large fins after all—are wet, so the bit of candle skimming over the water at the end of the dolphin striker, makes a perfect model of them. Many and many a live flying-fish I've caught, merely by putting a lighted candle at the scuttle at night-time; for then *in* they'll dart like moths at a flame. Many a dolphin too, I've hauled up by the bit of candle I spoke of. You've heard about the dying dolphin, youngster, I dare say. Well, it's no fable, I can tell you; for after they're taken out of the water, every quiver

they give as they lie gasping at your feet, brings out a new colour; at one moment they're all silver like, the next they're purple and gold, and the minute after, spotted all over with blue; you can see their agonies painted before your eyes as one tint trembles into another. But all this, boy, has nothing to do with what I wanted to say to you; only you see the thoughts *will* come into my head, and they run away with me now. I seem to get to have no more power over them than if I was dreaming. Do you know," went on the old Captain, "I've been thinking, Owen, as you've got such a fancy for clocks and watches, I'd tell you something about time; for, to know well how to make a machine to measure time, boy, we must have some notion of that which we want to measure. Well, did you ever think what time was, my little lad?"

"No, sir; I'm sure I never did," answered the boy.

"Time then, youngster," replied the Captain, "is the measure of the rate at which anything moves."

"The measure—of the rate—at which anything moves," echoed Owen, as he repeated the words slowly in an under tone to himself.

"So you can't make it out, boy, eh?" asked the old sailor. "Look you now! Aboard a'ship we measure the rate at which the vessel is going through the water by the log-line—that's a line with knots

all along it at regular distances, and a piece of wood which we call 'the log' at the end of it. When the log is thrown on the water it remains where it falls, unless, indeed, there are any currents running—but we'll put them out of the question just now; so, as the log stops in the same place, the line is drawn from off the reel it's wound upon, precisely at the same rate as the ship moves. Well, the knots I told you of are usually placed along the line at every 44th foot, because that's the 120th part of a mile, and the 120th part of an hour, you know, is half a minute; so you can easily understand if the ship is going a mile in the hour, one of these knots will run out every half minute, and if she is going 5 miles in the hour, why of course 5 of the knots will run out in the half minute then. Well, while one of the men heaves the log, another stands by with the half-minute glass, and according to the number of knots that have run out by the time the sand is down, so many miles—'knots,' as we sailors say—is the ship going per hour. Now you see, Owen, in this case the half-minute glass is the measure of the rate at which the ship is moving. But in the same way as we discover *the rate of moving by the time,* we might, if the ship always went at the same speed, discover *the time by the rate of moving.* Let us suppose for instance, lad, that we could make the ship go regularly 5 miles an hour, then every 5 knots along the line would stand for half a minute, and every 10 for a minute,

of course; so that when 300 had run out, we should know that half an hour had passed, or 'one bell,' as we call it at sea."

"But even if you *could* make the ship go regularly, sir," said Owen, "surely that would be a very funny way of telling what a clock it was?"

"I dare say it may seem strange to you, lad," replied the old sailor, "but still it's only by a similar process that we're able to tell what a clock it is in nature. *The earth, you see, is the ship we're all a-board, while the sun is our log floating in the ocean of space, and we tell the time simply by the rate at which the earth travels.*"

"But," laughed the boy, "you haven't any line to your log, to measure how fast the ship's going, sir?"

"Well, now, just fancy the log-line to be wound on a large reel, lad," returned the old Captain, rubbing his head to brighten his ideas, "—so large, indeed, that as the line ran out the reel would turn round once only in twenty-four hours; then, of course, it would not matter whether you saw the line or not, for you could tell the time merely by watching the reel revolve as the vessel went on. When it had turned a quarter round you'd know six hours had passed—half round, twelve hours—and once entirely round, that a whole day had gone."

"Oh, I see," exclaimed Owen, "then the earth is the ship and the reel as well."

"Ay, ay, that's about it, youngster. Now, there are three such logs," continued the sailor, "floating in space, which will serve us to measure our time on the earth by. And these are the sun, the stars, and the moon; but the worst of it is, they all tell different tales. You think, I dare say, youngster, that a natural day is twenty-four hours long?"

"And isn't it?" inquired Owen.

"No, lad," said the Captain; "but the first question to be settled is, what *is* a natural day? Well, let us see what goes on in the sky during this time. In the first place, we notice the sun to come up somewhere about the east, and to appear to ascend gradually higher and higher in the heavens, until mid-day, when it reaches its greatest altitude; then it begins to sink, seeming to fall lower and lower as the evening draws in; and at length it disappears altogether from our sight in some part of the west, or opposite quarter to that it rose in—having appeared to make the entire sweep of the sky above us, and to have kept, while it did so, more to the southern than the northern part of it. After this, the twilight sets in, and the stars begin to peep out, the brightest appearing at first, but as the darkness increases, more and more specks of light shine forth, till the whole sky is spangled over with them. Now, if we turn ourselves south, and fix our eyes on some of the most brilliant of the stars —taking care to select such as we shall be sure to

know again after looking away from them for some time—and refer their apparent places to some buildings or trees round about us, we shall find, after some few hours, on comparing these stars again with the objects we referred them to, that as the night has advanced they have shifted their places, and moved in a westward direction. Those *towards the east*, for instance, will appear to us to have *risen* from the horizon, while those which lie *about the west* will seem to have *sunk* towards it, and be noticed finally to disappear beneath it. Others, again, in the eastern quarter, will be observed to come up as if out of the earth, and, joining in the general procession, pursue their course with the rest towards the opposite point of the sky. After this, if we turn our eyes to the stars which are far above the horizon, and notice their movements, we shall find that, whereas those in *the extreme south* appear to describe only a small arc, or portion of a circle, in their course across the firmament, and to remain but for a short time in sight, the stars, as we progress towards the centre of the vault, continue to be visible for a longer and longer period, and seem to take larger and larger sweeps through the heavens, till some appear to describe precisely half a circle, and keep twelve hours above the horizon, those rising exactly in the east setting exactly in the west. Then, if we carry our eyes *farther*

northward, we shall observe stars again which in their motion just graze the horizon at its north point, or only dip below it for a moment, and others that never touch the horizon at all, but keep always above it, revolving in such a manner that we can see they would, in about twenty-four hours, complete an entire circle in the sky, while the circles described by them grow smaller and smaller as they approach towards one point, which seems to be *the common centre of all the movements, and which alone amidst the whole shifting train appears to be immovable.* We shall farther observe that the relative places of all the stars—with the exception of some two or three wanderers in the south—are *not changed among one another* by their continued movements, but that at whatever hour of the night they are observed, or in whatever part of the heavens they appear, they always form with each other the very same groups or figures as when first we noticed them. And lastly, we shall perceive, if we've patience to watch through a long winter's night, that those stars which we saw in the early part of the evening setting in the west, have again, as the morning comes round, risen in the east; while those which were rising when we first began to notice the heavens, have completed their course, and set just as we are ending our observations. Many and many a time have I watched these things, boy, as I paced the

deck in the night at sea, and I can behold the entire starry band now trooping before my eyes almost as vividly as I did then. But where did I leave off, lad, eh?"

"You were telling me, sir, what a day is," replied the youth.

"Oh! I remember," returned the Captain. "Well, you see, youngster, the course of everything in the heavens is to move from some particular part of the sky back to precisely the same place again in a certain number of hours. Now, astronomers, boy, call a day the length of time that elapses between the apparent departure of some celestial body from a certain point in the heavens and its apparent return to precisely the same point."

"But how can they tell," asked the little fellow, "when a star or the sun reaches precisely the same spot in the sky, sir? There are no marks up there to guide them."

"That's true enough, lad," returned the sailor. "But there's a very simple way of doing this. You've only to turn your face towards the south, and as you look through a small hole in the shutter or in a plate of tin fastened to your window, to fix your eye upon a sharp well-defined line at the corner of some building a little distance from you—such as the edge of a stack of chimneys—and then notice the exact time at which any star that you would know again disappears behind the edge of the

stack on two evenings following. This, of course, will give you the precise period that the star takes to return to the same spot in the heavens. You can make the same observation with the sun, only you must look through a piece of smoked glass then, and observe first the moments when one edge of the orb disappears, and then the time of the other's doing so, behind the same place. The interval between the vanishing of the two edges must then be halved and added to the time of the disappearance of the first edge, and by that means you will ascertain what you could not directly have observed—the time of the disappearance of the centre."

"So, then, a day," said Owen, "is the time that the sun or the stars take to return to the same place in the heavens as they were in twenty-four hours before."

"Hold hard!" cried the sailor, "not twenty-four hours, boy! for if we measure the day in the manner I've told you by the stars, we shall find it's but little more than 23 hours 56 minutes long, or very nearly 4 minutes short of the 24 hours, and that's what is called a *sidereal* day. If, on the other hand, we measure by the moon, the day is—on the average—24 hours and 54 minutes, or very nearly 25 hours long; and this is what is called a *lunar* day. Whereas, if we reckon by the sun, we find that the length of the day is never the same for two days

together. Sometimes it's more, and sometimes it's less than twenty-four hours. About the end of September the day is half a minute short, and about the end of December it's nearly as much too long. And it's only a very few times in the year that the day, as measured by the sun, is precisely 24 hours long.* Now this again is what's termed a *solar* day."

"Dear, dear! how odd!" cried the bewildered little fellow; "for if a day in nature, as you say, Captain Jones, is seldom twenty-four hours in length, all our clocks must be wrong."

"Nay, nay, my lad, that doesn't follow," replied the sailor; "for if you were to keep noticing the time the sun takes to return to the same place overhead day after day for a whole year, you'd find, at the twelvemonth's end, on adding up the lengths of all the different days and dividing the total by the gross number of days in the year, that you'd have what's called an *average* of 24 hours to every day throughout the twelve months. For if you remember, I told you that some of the solar days were too long, and some too short; so that at the year's end, you see,

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* The times above referred to are generally a day or two about the 10th of February, the 14th of May, the 26th of July, and the 2nd of November in every year. The solar day, however, at such periods, does not coincide with the clock day in any other way than its length, for when it is XII by the sun it is always at these times some few minutes before or after XII by the clock.

the long ones just make up for the short ones, and that what's called a *mean* solar-day; that is to say, it's not any particular solar day, but an *average* of the whole of the solar days throughout the year."

"I can't quite make out what you mean, sir," interrupted Owen, "because I don't know what an average is."

"Well, youngster, that's not very difficult to explain to you," answered the sailor. "Now, suppose I was to give you 6*d.* this week, and 1*d.* next week, and 5*d.* the week after, and 1*s.* the week after that; and then suppose you wanted to find out at the month's end how much I'd given you *on an average* each week—that is to say, not in any one week, but how much I should have given you if I had portioned the money out equally through the whole time. Let us see how we should have to set to work to find out that. Why first we should add the sums all together; we should say 6*d.* and a 1*d.* and 5*d.* and 1*s.* make 2*s.* or 24*d.* in all. So you perceive I should have given you 24*d.* altogether in the month; and then dividing this amount by the number of weeks I'd been paying it to you—and that would be 4 of course—we should find that I had given you just 6*d.* every week—*on the average*, as it is called. For you see, lad, it would come to precisely the same thing at the month's end, if I were to pay you 6*d.* a week regularly for 4 weeks

running, as if I were to give you first 6*d.*, then 1*d.*, then 5*d.*, and then 1*s.*"

"That's very plain, sir," said the boy.

"However, to impress the point on your mind, it's better, perhaps, to put it to the practical proof, so here's 6*d.* to begin with," chuckled the good-humoured old man, as he drew the piece of silver from his waistcoat pocket and placed it in the boy's hand, saying, "Now mind, youngster, I shall give you a different sum for three weeks after this one, and if, at the month's end, you can tell me how much I've given you every week—*on the average*—why you may keep the whole. But if you can't tell me the average amount I've paid you, why I shall expect you to give the money all back again. So keep a sharp look out a-head, for this'll brighten your wits a bit, I'll warrant."

The little fellow laughed, as he answered, "I should recollect what an average is, sir, without that, I think; though you're very good, I'm sure, to teach me in so nice a way."

"But bless us and save us, where was I, Owen!" said the old Captain, tapping his forehead as if he were sounding a cask to see whether there were anything in it. "It's all gone right out of my head again; you see it's so strange, boy, I can remember everything I learnt when I was a youngster, more than half a century ago, whereas, if you were to

ask me I really don't believe I could tell you what I had for dinner yesterday. Let me see, now, what *did* I have?" added the sailor, half to himself. "It wasn't pickled pork; no, no, we finished that a good bit back—it could'nt have been eggs and bacon, for that always disagrees with me—Irish stew, no, that's not it either—well, it's no good trying—but I knew I couldn't before I began. What was I saying, though, lad?"

"You were telling me, sir, about the average—a—a—the average solar day, didn't you call it, sir?" answered the boy, hesitating over the hard words.

"Ay, ay, youngster, that was it," exclaimed the sailor. "Well now, youngster, we'll put the names of the different kind of days into plain English, for it's the hard crack-jaw terms that puzzle boys like you, and we'll say there's a star-day, a moon-day, a sun-day—though the last doesn't mean the day after Saturday, mind, but the day measured by the sun—and an average or mean day. A better name for the last, however, would be a clock-day. Now each of these days is of a different length, simply because they are measured by different logs. The star-day is measured by the time the stars take to return to the same spot in the heavens; the moon-day is measured in the same way by the moon; and the sun or solar day in like manner by the sun; while the average or mean day is no particular day at all, but simply one that is come at by adding

together the length of every one of the sun or solar days throughout the year, and dividing the total by the entire number of days, in order to make them each of the same length—just as you are to do, Owen, at the end of the month with the four weeks' different pay I'm to give you. Do you understand it now, lad?"

"Perfectly, sir, thank you," replied Owen.

"Well, lad," continued the old man, "the length of the days, and even the years on the earth, is different, according as they are measured by different logs in the heavens. Now, you'd hardly think it, I dare say, but a star-year is just one star-day longer than a sun-year; that is to say, the star-year consists, in round numbers, of 365 solar days, and of 366 star-days. For if you were to observe, in the way I told you, the return of the sun and any star you please to the same spot overhead, day after day, for a whole twelvemonth, you'd find, at the year's end, that the star had returned 366 times, and the sun only 365 times. So that, as a day is the length of time between the return of any celestial body to the same place in the sky, the star-year must be one day longer than the sun-year. And now, my little man, I'll tell you the reason of this."

"Oh! do if you please, sir," asked the lad; "for I can't make it out at all, now; and I can always remember a thing so much better when I know the reason of it."

"Well, my boy," continued the sailor, "if you

were to set out in a ship, and keep on sailing to the *west'ard* till you got right round the world, and came back to the place you started from, you'd appear to have *lost* a day; that is, though you might have entered every day in your log as regularly as the day passed while you were on the voyage, you'd find when you'd got back that what you called Monday the 21st of May, for instance, the people who had stopped at home would declare was Tuesday the 22nd."

"Is that really true, sir?" inquired the astonished lad.

"*True*, boy? Why, it's been done over and over again," answered the Captain. "And what's just as strange, if you kept sailing to the *east'ard*, instead of the west'ard, as before, you'd find, on your return, that you'd *gained* a day then; and that what you reckoned up as Monday, the 21st of May, as we said before, the people at home would stand you out hard and fast was Sunday the 20th."

Owen could keep his countenance no longer, and bursting into a hearty laugh, at the apparent absurdity, said, "Well, I never heard of such strange things before."

Old Captain Jones was tickled at the boy's mirth, and having indulged in a good chuckle himself, said, after a few minutes' rest, "Now suppose, youngster, you had been a year away, why, of course, on your return you would have had, if you'd

been sailing to the east'ard, just 366 days to your year, precisely as there are 366 days to the star-year."

"Yes, sir, I see," said Owen; "but *why* it should be so I can't make out."

"Why, boy," replied the sailor, "you would have been sailing then—for we supposed you to go, you know, *from west to east*—in the *same* direction as the earth itself moves; and since the earth goes round so many times in the course of the year, and you yourself in the ship had gone once round it besides, in the same time, why, of course, it must have appeared to you to have made one turn *more* than the usual number; for there is your own turn round it, remember, to be added to the others. Whereas, if you had been sailing in the *opposite* direction to the earth's motion—or *from east to west*—the earth must have seemed to you to have made one turn *less* than usual; because, while it was going round so many times one way, your ship would have gone round once the contrary way, and this revolution, of course, would make the year appear to be one turn short."

"I think I begin to understand a little what you mean," remarked the lad, thoughtfully.

"Well now, youngster, the sun, you know," answered his friendly tutor, "appears to go round the earth from east to west, and to do so 365 times in the course of the year. But while the sun is doing

this, astronomers have discovered that it seems also to be continually shifting its place among the stars, so that it appears to pass through one regular line of them, and to make the entire circuit of the heavens in the twelve months. That is to say, the sun is found to be among exactly the same stars at the twelvemonth's end as it was twelve months before. Well, this apparent yearly revolution of the sun among the stars, boy, takes place *in the opposite direction to its apparent daily revolution round the earth*, which you know is from east to west, while the other is from west to east. So you see, it comes to the same thing as the ship sailing round the earth the contrary way to its motion. The consequence is that, whereas the stars appear to go round the earth 366 times in the course of the year, the sun appears to go round it only 365 times in the same period; because it seems while it's doing this *to go round once in the reverse direction.* For the earth really turns round 366 times in the year, though we fancy, from there being but 365 days and nights in that time, that it makes only the latter number of revolutions. The fact is, my boy, that owing to the apparent backward motion of the sun among the stars, the earth has to make the 365th part more than one turn round every day, in order to bring the sun into the same place over our heads, or, in other words, to finish the natural day. So that it is clear

that in the course of the year the 365 revolutions, with all the 365th parts added to them, must be equal to 366."

"Oh! thank you, sir," exclaimed Owen; "I think I can make out what you mean."

"But let us understand, Owen, before we go any further," proceeded the old man, "what a year really is. Well, I told you, if you remember, that the sun, while appearing to come back to the same place over our heads, day after day, seems at the same time to be moving in a contrary direction through the stars. Now if the sun's course through the stars be watched from time to time, and his different positions among them be pricked down on a chart, in the same way as we mark the course of a ship, over the different parts of the earth, we shall find that it appears to make the entire circuit of the heavens, and to get round again in a certain period to the very same point among the stars as that which it previously set out from. It is this period that constitutes what is called a *year*. So mind, lad, a *day* is the length of time that the sun or any other heavenly body takes to travel from a point over our heads, round again to the same point; whereas a *year* is the length of time that the sun takes to travel from any place among the stars, round again to the same place among the stars."

The boy nodded assent, and the Captain proceeded.

"You must bear in mind then, lad, that the sun-

year is not exactly 365 days and a quarter long, but a little better than 11 minutes short of that period; for as the return of the seasons depends on the sun-year, we shall find, if the exact length of it be not taken into account, that our longest and shortest days will be falling at different dates in different years; and, indeed, the return of our spring, summer, autumn, and winter, rendered altogether vague and unsettled."

"I think I shall not forget that, sir," said the lad.

"Now," continued the Captain, "we know what a sun-year is, and a star-year too. But as there was a moon-day as well as a sun and a star-day, so is there a moon-year as well as a sun and star-year; for the moon, while it seems to go round the earth from day to day, appears to traverse the stars, and to make the tour of the heavens in a certain period, just the same as the sun does—though in a much shorter time. Indeed, so much shorter a time does the moon take to do this, that the period of its return to its former position among the heavenly bodies, is called a *month* rather than a *year*. Accordingly, the lunar or moon-year is made to consist of 12 months or lunations, as they are called. Then, as there are nearly 29 days 13 hours in each month, there can be but barely 354 days 9 hours in the moon-year; so that this kind of year, you see, is no less than 10 days 21 hours shorter than the sun-year."

"But you know, sir," said Owen, "there was not only a star, a sun, and a moon-day in the same way as there is a star, a sun, and a moon-year, but there was an average or mean day, as you called it, sir. Is there then an average or mean year, Captain Jones?"

"Very well said, my little man," answered the sailor, "that's just what I was going to tell you. Well, you see, in olden times, many, many years ago—the Romans (they were a great people who lived a long time back in Italy) were in the habit of calculating their year by the moon.* But as the moon-year was several days shorter than the sun-year, which regulates the return of summer and winter, why they found, that after a certain period, their summer used to get round to the same month as their winter had previously fallen upon—which is the same thing as if our Midsummer-day was to come at Christmas time. Thus the Roman year got to be so fickle and unsettled like, that the High Priests, in those times, were obliged to publish a table to tell the people when the spring and other seasons began; while the magistrates and other great folks, in order to make the seasons fall as near as possible in the same months, used occasionally to lengthen or

* The Roman lunar year was 61 days short of the solar year. It consisted of only 10 lunations instead of 12, and had an extra month thrown in—or "intercalated," to speak technically—every third year. The intercalated lunar year is termed the "*lunar embolimic year.*'

shorten the months just as the fancy took them. At last, however, the poor Romans got into such a confusion about their days, and months, and years, and seasons, that Julius Cæsar, who was one of their greatest kings like, called an eminent astronomer* to his assistance, and it was then arranged to change the mode of reckoning by the moon-year, to that of the sun-year. Still, as the sun-year was 365 days and nearly a quarter long, the question became, what were they to do with the odd hours every year? Well, after twisting and turning the matter well over, they settled that it would be best to have two years, one of 365 days long, and the other of 366, and to make the year of 365 days go on for three years, and the one of 366 days occur every fourth year; that is to say, youngster, they cast the quarter of a day at the end of each year over to every fourth year;† and as four quarters must make a whole, they added one day then to the 365 days in the other years."

"Oh! I see," cried the little fellow, growing more and more interested in the subject. "That was very clever; wasn't it, sir?"

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* Sosigenes of Alexandria.

† The Roman intercalary day, or, in other words, the extra day inserted in the calendar every fourth year—as our 29th of February—was made to fall on the 6th day of the calends of March; that is to say, this sixth day was reckoned twice every fourth year, and so got to be called "*bis sextus dies*," whence the name of our "*bissextile* year."

"Yes, that it was," replied the sailor, "and it occurred about 45 years before the birth of Christ. You may have some notion of the state that the Romans' reckoning was in before that time, when I tell you they were obliged to pass an act of parliament like, to make the year previous to that in which the change took place 445 days long. It was owing to this circumstance that that year was called "the year of confusion." Well it might have been, too, I'm sure; for how the captains managed about their quarter's pay in that year is more than I can tell. All I know is, I shouldn't have liked to have served in their merchant service 445 days for a twelvemonth's pay. And what the landlords did about their rents, or the old Roman ladies, with long annuities like, about their dividends at that time, puzzles me sadly to make out. Dear! dear! it must have been a nice muddle to be sure!"

The couple paused for a while to amuse themselves with fancying all kinds of strange things that must have come to pass at such a time.

Suddenly, however, the old man broke off with his customary "Dear, dear! what will become of me! I can't remember a thing now, unless it's what happened to me when I was almost a youngster like you, Where on earth were we?" he inquired for about the hundredth time.

Owen smiled, as he reminded the Captain that he had stopped at the year of confusion.

"Ay, ay, lad, so we were," tittered the old man, "and we've not got out of the confusion yet, I can tell you. Well now, Owen, I was telling you that the sun-year was not quite 365¼ days long."

"Yes, sir," replied the boy, quickly, "you said it was a little better than 11 minutes short of the quarter."

"Bravo! bravo!" shouted the Captain, clapping his hands; "what would I give to have your noddle, you young rogue you." And as he said so he took hold of the boy's hair and rolled his head playfully about, saying, "You can't sell it me, can you? But we must keep to our bearings, for I've still a little more to tell you before you go home. You see then, lad, the sun-year is, as near as we can come to it, 11 minutes and 10 seconds short of the 365¼ days. Consequently, when his Roman majesty got overhauling the reckoning, he and his astronomer didn't set it straight after all, but made the four years altogether 44 minutes and 40 seconds longer than they were in nature."

"But surely, sir," remarked Owen, "that didn't make much difference."

"Didn't it though!" answered the old sailor, "let us see now. Well, Julius Cæsar, you know, was trying to give us an *average* sun-year; but his year being more than the average period, the consequence was, though the error was trifling for 4 years, that when it came to hundreds of years the difference got

to be pretty plain; for you'd find, if you calculated it, that in about every 129 years the seasons would, according to Cæsar's average year, be coming round one day earlier than they used before that time. So, in about the 15th century, the people got to wonder what on earth had come to their longest and shortest day. Instead of falling towards the end of June and December—as those days should, if the average year had been exact, and as history told them they used—why they'd wriggled themselves up to the other side of the middle of those months; that is to say, the time of the seasons had got out no less than ten days since the reckoning was altered. Accordingly another gentleman took the matter in hand, and he was Pope Gregory XIII. It's from him we have our present average sun-year, or *Gregorian* year as they call it, in contradistinction to the *Julian* one. Well, lad, Julius Cæsar arranged that every year which was exactly divisible by 4 should consist of 366 days, and all the others of 365; but Pope Gregory finding that this made the year too long by about one day in 129 years, settled to do with the hundredth years what Cæsar had done with the other years; that is to say, he determined that only each 400th year should consist of 366 days, and every other hundredth year of merely 365 instead of 366, as *all* the hundredth years would have done according to the Julian arrangement—since every one

of them is capable of being divided by 4 without any remainder. So you see, boy, Pope Gregory shortened the average Julian year in this manner by three days in every 400 years."*

"Dear, dear, how clever!"

"But Gregory didn't finish there, lad," continued the Captain; "for you know I told you the seasons had got about ten days ahead of their proper dates. Accordingly, he ordered that after the 4th of October, 1582, ten entire days should be struck out of that year, and that the dates should run on—not as usual the 4th of October, the 5th, 6th, and so forth—but jump right away from the 4th to the 15th. So you see, Owen, in the year 1582 there was really no 5th of October, nor a 6th, nor a 7th, nor indeed any day between the 4th and 15th."

"Bless me, how odd!" said the astonished lad. "Suppose one's birth-day had fallen on one of those days—and somebody's must, I fancy—why, they wouldn't have had a birth-day at all that year."

"That's true enough, youngster," added the sailor,

* It will be found, on calculating, that whereas the Julian arrangement made the average year 11 minutes 10 seconds longer than the solar or tropical year, the Gregorian arrangement makes it only a fraction more than 22 seconds longer. This amounts to 2 hours 28 minutes and 40 seconds in every 400 years, which is scarcely a day in 3000 years; or, but 2 days 14 hours 24 minutes in every 10,000 years. This, as Sir John Herschel observes, is surely "more than sufficient for all human purposes—those of the astronomer excepted, who is in no danger of being led into error from such a cause."

tittering. "I only wish they'd have done the same thing in my time, and then I might have thought myself a year younger, you know. But to finish, Owen—for it'll be getting late—it wasn't until the year 1752 that the change of style, as it is called, took place in our own country, and then eleven days were struck out of the calendar of that year; so that the last day of 'Old Style,' as the phrase goes, was the 2nd of September, and then the date made a leap right over to the 14th, 'New Style,' instead of going straight on as usual to the 3rd, 4th, 5th, and so forth; cutting all the days between the 2nd and 14th of September completely out of existence. Therefore, if you ever hear any one telling you of anything having happened on the 3rd or 4th of September, 1752, or indeed any day between the 2nd and the 14th of that month, in that year, you can be certain it's a taradiddle; for, you see, there never were any such days in the world."

"I understand, sir," said the boy. "Oh! shouldn't I like to have a game with my brother Hugh about it! I'll tell him when I go home that there was no person ever born or died between the 2nd and the 14th September, 1752—that no work was done, that no shops were open, no coaches ran, and no bread was sold to the people—indeed, that no one did anything, ate anything, or slept a wink for the whole of that time. Oh! won't it be a bit of fun, Captain Jones?"

"Well, boy, I'll tell you something else, too," added the old man. "You can say besides, that there was a year once in England that was only three quarters, or nine months long. And when they ask you what year that was, say it was the year 1751; for before that time, the year always began here on the 25th of March, and so indeed did the year 1751; but the one after that was ordered to begin on the 1st of January; so that as 1751 commenced on the 25th of March and ended on the 1st of January 1752, it could have been only nine months long, you see. Well, do you know, Owen, that's the only year I ever heard tell of that a poor midshipman could have got his half-pay."

"Indeed, sir. But why?" eagerly inquired the boy.

"Because they say on board a ship," returned the Captain, "that a middy's half-pay is three farthings a year, paid quarterly. So, you see, it was only when the year was nine months long, that the reefers could have received their quarter's dividends."

Owen chuckled at the Captain's jokelet, and rose from his seat to take his departure.

"Heave to, youngster!" cried the sailor; "for I've yet to tell you what was the drift of my spinning you all this yarn about the different kinds of time. You see you've got a watch as well as a clock now; that

is, you're going to measure the length of the hours in the average, or clock day. But suppose the instruments you measure by are wrong. Suppose the hours that your timepiece marks are too short or too long, why, the day will seem to be either too long or too short also. Well, then, how are you to tell whether the time that your watch or your clock shows is the proper average or mean time, lad?" The old man paused for an answer.

Owen thought for awhile, and then shook his head as he said, "I'm sure I can't say, sir."

"Well, then, of all time the truest is star time, because, as the stars never appear to change their places among one another, like the sun and moon do among them, their time of returning to the same point overhead doesn't vary every day as sun or moon time does. Besides, star time is the easiest to observe correctly. Now, you know I told you before how to find out when a star got back to the same point in the sky. Well, you're to do this for two nights running, and then, if on the second night the same star disappears 3 minutes 56 seconds sooner by your clock or watch than it did on the first night, it's a certain sign that the timepiece is going true; and if it doesn't show this difference, why, the timepiece must be regulated accordingly. Now, if you'll come to me to-morrow, I'll try and make you understand how it is we know that the earth's round, and how we can measure it right

across, though we can't get through it; and how, too, we can tell it's moving, although all the houses and trees, and things upon it, appear to be standing still. There *now*, we've done, and so you weigh anchor, youngster. Come, don't you know what weigh anchor means? Why, hoist all sail and be off. I'm sure you must be tired; for I know *I* am—as tired as I was of salt junk when I first went to sea."

Owen wished the old man good night, and thanking him again and again for what he had given and what he had taught him, left the parlour, promising to make the star observation before he went to bed that night.

The boy had got half-way across the garden in front of the cottage, when the Captain tapped loudly after him at the window, and beckoning Owen to return, shouted to him through the panes to be sure and come early on the morrow. And here he added, as he raised the sash just high enough to thrust a little paper cone underneath it, "give these sugar-plums to my little toddles, with a big kiss, remember, from 'Mitter Jone.'"

CHAPTER IX.

THE BOY LEARNS HOW TO TELL THE SHAPE AND MEASURE THE SIZE OF THE EARTH.

WHEN Owen reached home, he set to work immediately that the stars began to peep out to make the observation described by the Captain.

Having selected a bright star—a large one in the centre of three that appeared to be nearly in a line with each other—he got his brother Hugh to note the exact time as he cried out "now," the moment he beheld it disappear behind the edge of the blacksmith's stack of chimneys; and the little fellow was overjoyed to find he could make the observation much easier than he expected.

This was the first experiment Owen had ever made with the stars, and the interest he took in it was increased as he watched the course of the little specks of light, and recalled what the sailor had told him about their movements; for he noticed that all the old man had described came true.

After this, the boy led his brother to the front

window of their little bedroom, telling him that Captain Jones had said there was a point in the north which all the stars appeared to move round, and that the circles they made in the sky became smaller and smaller the nearer they got to this point.

But though the two watched patiently for a long time, and noticed star after star disappear behind the western side of the mountain, in front of the cottage, they could discover no such fixed point in the heavens.

It was late that night before Owen closed his eyes, for his thoughts, turned into a new channel, kept on sweeping along, one after another, almost in the same endless procession as the little points of light he had been gazing at. He had never noticed the motion of the stars before, and the little fellow was full of wonder at the new discovery. What could it mean? Where were they all going to? What would they look like if a person could get near them? Were they lamps or what? and where was their use to us? and why had they been set up there to move on and on, year after year, as he felt assured they must have done from the beginning of the world, and would continue doing till the end of it?

Hugh and Owen lay awake in their beds, long speculating, in their own simple way, upon all these matters; and when Hugh—tired by the day's labour—had fallen asleep, Owen still kept on pondering

over the fresh marvel, and before he closed his eyes that night the little fellow, enraptured with the strange beauty of what he had found out, thanked God heartily that he had got to know so much of His goodness and power.

Early the next morning, Owen was busy thinking over all the Captain had made him acquainted with the day before, and what the old man had promised to tell him that afternoon.

The lad remained in bed, longer than usual, wondering how it was that people could make out the world was round.

"Everybody says it is so," he whispered to himself—"Mr. Wilkins and Captain Jones, and all. And I remember yesterday, the Captain was very particular every time in saying the sun and stars *appeared* to go round the earth. But how can they tell whether they only appear to do so or not?" he asked himself again and again. "I'm sure the earth looks quite flat to me, and when I've been on the top of the Garth," he went on, "I've often thought I could walk to the end of the world. I've fancied it was like the top of a big table, and that one could go to the edge of it, and look right down over the sides, like into a great deep well; and many a time I've wondered, if we could only peep over the brink of it what we should see there. Still it can't be flat; for Captain Jones told me that people had

sailed all round it. Then why should the ground seem to go straight along? A round never looks like that. Besides, I've heard father say that all water finds its own level, and that's the reason he uses his spirit-level to tell when things are perfectly even on the top. But if water *does* find its level, the sea must be quite flat, and then how could persons sail round it. Besides, if the world was really round, all the sea would run off it, as water would off a ball. Still, Mr. Wilkins, when he was talking to me about gravitation, and showing me how it was people didn't fall off the earth, took a ball of yarn, and said the world was like that. Yes, he *must* have meant it was a ball; I wanted to know more about it then, but didn't like to ask. They must mean it's a ball, I'm sure. Captain Jones, too, said the earth turned round 366 times in a year, and that when I went to him to-day he'd explain to me how the things upon it—trees, buildings, and all—those were the very words he used—were moving, though they every one seemed to be standing still. I can't make it out any how. My bed doesn't feel to be moving."

Then the boy remained perfectly still for a minute or two to see if he could detect any motion in the little imitation chest of drawers that served him for a couch. "No!" said the lad, "and I'm sure if the bed had stirred in the least, I should have felt it then; for

when I'm on old Jack, I know very well I'm being carried along. Besides, the day Joe Powell, the wagoner, gave me a ride in his wagon up to Builth, I could tell well enough when we were going on. How *can* they, then, make out that the world's moving if it isn't possible to feel it."

Accordingly the lad longed for the time to come when the Captain was to explain the puzzle to him. And when he had risen, he went to the dingle, and sauntered along by the brook side, imagining all manner of simple things that he fancied might serve as a solution of the problem.

As soon as Owen judged it was mid-day—and he could tell by the shortness of the shadows of the trees when it was about noon—he turned his steps towards the sailor's cottage. On reaching the bridge he looked up the village to see if the Captain was sitting in his usual place in the garden.

The old sailor, who was warming himself in the sun, no sooner caught sight of Owen Evans, than he beckoned to him as he cried—"Here, youngster, I've been waiting for you the last hour."

Owen replied, as he advanced towards him, that he was afraid of troubling him, or he should have been with him long before.

In a few minutes the Captain and the boy were again seated in the little parlour.

"Now let me see," said the old man, "what did I say I'd tell you about to-day? I'm sure I forget. It was as much as I could do to remember you were coming, and I shouldn't have done *that* if it hadn't been for Mrs. Pugh reminding me of it, for she heard me, you see, call to you through the window last night. If it hadn't been for that you'd have had no pudding, youngster, for dinner to-day. However, I've settled she's to make you a nice—nice—let me see, what *did* I settle it was to be? A green gooseberry—gooseberry, no, it couldn't be that! they've been out of season months now. It wasn't batter either, I know, because I told her boys liked fruit best. Could it have been—been plum, then? No, no, for there isn't a plum-tree in our garden. Well, I can't tell; its apple, or currant, or jam roly-poly, or something of that kind, boy. But you'll see it when it comes, and I'll lay my life you'll make nearly as big a hole in it as I did in that cherry and currant pie Mr. Peace gave me at the King George's Head, at Gravesend, the day I joined the 'Edinboro' Castle,' my first ship. Didn't the waiter hoist his eyebrows when he saw how I'd cleared all the fruit out of the hold of that pie!" And at the recollection of the youthful feat, the old sailor broke out into a hearty laugh, chuckling again till the tears streamed from his eyes.

On drawing his handkerchief from his pocket, he could scarcely find a part of it wherewith to wipe the tears from his cheeks, for he had tied it into so many knots that it looked more like a bunch of onions than a yellow bandanna.

"Dear, dear!" the old man cried, as he surveyed the ball, "now what on earth do all these knots stand for? Every one of them, I know, was to remind me of something very particular, but what on earth that something was, is more than I can tell. Now I come to think of it, too, I do verily believe I tied one just after you'd left, to make me remember some matter I wanted to tell you. But you see the worst of it is, lad, when once I've tied a knot I don't like to undo it again, because I fancy it stands for something important that I ought to recollect, and if I untied it, why it would seem like chucking the whole thing overboard from one's mind. So there I go on putting knot after knot in my handkerchief, until I get it into a hard lump, and then it seems for all the world as if I was wiping my eyes with a cricket ball. At one time I tried to remember things by tying bits of string round my little finger, but that was all the same. It was as hard to know what the strings meant as it is with the knots in the handkerchief; and I declare, my fingers used to be half covered with cord rings before the month's end; so that

the difficulty I had to wash my hands then, is more than anybody would believe. But what was I to tell you about to-day? I've been trying to remember it half the morning, and can't get at it any how."

"Oh, if you please, sir," replied Owen, "you said you'd explain to me how people knew the earth to be round, and how they measured it, and how they could tell it was moving."

Then the lad informed the old man that he had made the observation as directed. Owen told the Captain, moreover, what he had noticed about the movements of the stars, and that he'd been thinking all the morning over what he was to learn that day.

"There's a good little fellow," cried the sailor, at the conclusion of the tale; "and now we're going to see first, if we can't make out the figure of the earth. Well, then, I suppose, Owen, you fancy it's the same sun you see go over your head every day? You don't think there's a fresh one comes up every morning, do you?"

"Why, no," replied the lad, "that would be funny indeed, sir."

"So the question is," continued the sailor, "what becomes of the sun after it sets of an evening? Where does it go to? And how is it that it manages to come up again the next morning at the

opposite quarter of the earth? For you know, lad, the sun sets in the west and rises in the east."

"I begin to see, sir, what you mean," answered the boy; "it must go along under the earth, of course."

"To be sure it must. You should remember, too, my boy, that it's not only the sun that seems to move over the earth every day, but the moon and stars all appear to do the same," added the old man; "consequently, what we want to settle is, how is this done? Well, there must either be a subterranean passage—that is to say, a passage under the world for them to travel along—or else there must be a hole right through the earth. But a hole in the middle of the earth, you know, wouldn't do, because the stars couldn't all pass through it without being jammed together like. And perhaps you noticed last night, when the stars come up in the east, they're just as wide apart as when they go down in the west, and the whole of them seem to be altogether as broad as the earth."

"Yes, I noticed that myself last night, sir," was the little fellow's answer.

"Well, then," proceeded the sailor, "there must be a way for them to go *under* the earth rather than *through* it. So you see, Owen, what we want to know now is this—do they go straight along under

the earth, or is there a vaulted sky underneath us, just the same as the one above? Now how do you think, lad, it's possible to come at that without seeing it?"

"I'm sure I can't say," replied the boy, after thinking awhile.

"Look you, Owen; if you'd known how to observe the rate at which the stars moved last night, you'd have found that they travelled through equal distances in equal times—that is, you'd have found them journeying at the same rate all the time they were visible to you. For on observing those which rose exactly in the east and set exactly in the west, and which take, as I before told you, just upon twelve hours to go right across the heavens, you would have discovered that they would have done exactly half the distance in exactly half the time; or a quarter of the distance in a quarter of the time. You'd have found, too, the same uniform rate of motion among all the others. Therefore we can but suppose the stars, after they leave our sight, to keep on travelling at the same rate as they do while they remain visible to us. Accordingly we must believe that those which rise exactly in the east and set exactly in the west, go through an equal space underneath the earth to what they do above it—since they not only remain just upon twelve hours visible, but are precisely the same time hidden from us. For as there is no reason

for us to imagine that their rate of motion is altered after their time of setting, why, we must come to the conclusion that they have to journey through the same distance underneath us, when they're out of sight, as they seem to travel through the sky above us."

"Yes, of course they must, sir," said the little pupil.

"Well, then," went on the sailor, "the stars couldn't go along in a straight line underneath the earth; because, you see, boy, a straight line across the half of a circle is what's called the diameter, and that's only about one-third of the length of the line which goes round the circle. Consequently, if the eastern and western stars passed immediately straight under the earth, they should travel the distance below it in one-third less time than they took to do the half of the circle they describe above the earth: that is to say, they should remain above the earth not quite 14½ hours, and be hidden from us but a little more than 9½ hours. But they remain, as I said, just as long hidden from us as they are visible to us. Therefore, since they must be travelling at the same rate under the earth, as they appear to do over it, it's clear they must be going through the same space, and completing the circle they left half unfinished when they disappeared from our sight. So you see, Owen, we're able to tell by this means that there's a sky underneath us just the same as there is above

us, and the sun, moon, and stars all appear to traverse that hemisphere, or half-globe, the same as they do our own."

"I'm sure I ought to be much obliged to you, Captain Jones, for all the trouble you take with me," said Owen; "but you've made it quite plain to me now, sir."

"Well, so far so good, lad," replied his tutor. "We've got one step for'ard at least. Now, you see, we want to find out what is the shape of the earth that is between these two skies. Is it a large flat piece of ground with an upper and an under side to it like a sheet of cardboard, and resting on fixed supports, like the top of a billiard table; or is it a round globe like a ball, and floating in space like a balloon? But let us say it's flat to begin with, and see if we can make out whether it's square like a draught-board, or round like a tambourine. Well, if you go on the top of the Garth, or any high place, what do you see?"

"Why, I see, sir, the earth spread out flat at my feet," answered the boy, "for I've been up there often. And as I've looked away into the distance it seemed as if I stood in the centre of the world, and the mountains far away appeared to form a ring right round me."

"Very good, boy, and if you'd been to sea," added the sailor, "you'd have seen the ocean about you

like a perfect circle; and let the ship journey on as it would, day after day there would be the same disc of water round the vessel, which would always seem the central point of it—the same as, if you'd been atop of Snowdon, you'd have seen the earth spread out like a large round plate, and yourself still forming the middle point of it. Now, lad, if the earth is flat and round, like a tambourine, as we said, it can't have so many centres that each, wherever we go, shall appear to be the middle of it."

"I should think not," remarked the boy.

"Besides, what could it rest upon?" added the Captain. "The old Indian philosophers imagined that there was a great elephant underneath it; but some sharp fellow, like you, Owen, suggested that the elephant itself would need something to stand upon. Whereupon the sages came to the conclusion that there must be a tortoise under each of its feet—though what supported the tortoises the wiseacres didn't trouble their heads about. Well, then, since the earth can't be flat, how do we know that it's spherical? Now you go and fetch me one of the oranges out of the side-board drawer there."

The little fellow did as he was bidden, after which the old man directed him to wheel the table into the middle of the room and to set the orange in the centre of it.

When Owen had done this the sailor proceeded to say—

"Now you go and place yourself in one of the corners of the parlour, and tell me how the orange looks to you."

The boy placed himself in the position indicated, and said, "It seems to me, sir, like a round."

"Well," continued the Captain, "walk over to the next corner, and tell me how it looks there."

"It seems just the same," cried the lad, as he shifted his place to the other angle.

"Go ahead, youngster, and keep your eye fixed on the orange all the while."

"It still appears the same round, sir, as when I first looked at it," remarked the boy, speaking as he went.

"Go on," cried the Captain, "go right round the room, so that you may see the orange from all quarters."

"There's no difference that I can see, sir," added Owen, as he continued his tour.

"And do you notice, lad," asked the sailor, "not only does it appear always round to you, but from whatever point you behold it, you seem to be looking straight at the middle of the circle?"

"Yes, that's quite right, sir," rejoined the Captain's little pupil.

"Now you've been all round it," said Captain Jones, "we'll put it on the ground, and you shall look down upon it."

"It appears just the same whichever way I look at it," said the lad, as he placed the orange at his feet, and stood gazing at it.

"Give it me, Owen," said the old man, "and let me hold it as far as I can above your head," and as he did so, and stretched his arm high in the air while the boy held back his head, he added, "there, do you see, it's still the same figure, is it not?"

"Quite the same, sir," replied the lad.

"Well, then," said the sailor, "you've seen it from every point of view. You've been right round it, you've looked over and under it, and still it's always appeared to be the same figure to you. And that figure a circle having the point your eye fell upon for the centre. Now do you understand how it is my little man?"

"Yes, I can tell what you mean, Captain Jones," replied the lad; "you would say, as all persons see the earth to be round from whatever part they look at it, and fancy themselves to be right in the middle of the circle they see about them, that its shape must be that of a ball. Isn't that what you mean, sir?"

"To be sure it must, boy," observed the Captain,

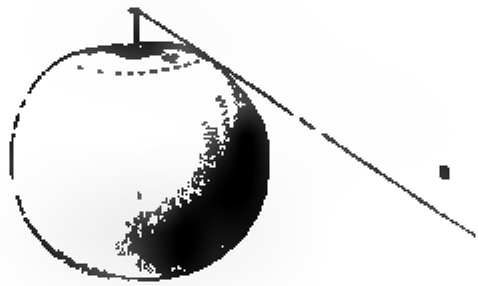
"*for a globe is the only body that can appear as a circle from all points of view.*"

"But, sir," exclaimed Owen, "the orange didn't appear to me quite like the world does; for the earth, when I look at it, seems a flat circle like, and the orange, I could see, always bulged out in the middle."

"Very true, boy, very true," returned the sailor, "but the orange was so small that you could always see one half of it, and the earth is so large that your eye can take in but a small portion of its surface at once. If you were a fly on that orange, Owen, or an ant—and even then in comparison with the size of the earth, you'd be bigger than the greatest giant that ever lived—you could only have seen but a little way over it, and how then could you have told whether or not it bulged out, as you call it? Still," continued his goodhumoured teacher, "we can tell by certain observations that the edges of the circle we always see wherever we stand on the earth, are lower down than the point from which we ourselves are looking. Now, lad, you run into the kitchen, and fetch me a bit of silk, and a pin or two."

When the boy returned, the Captain tied one end of the silk round the top of the pin that he had previously stuck in the rind of the orange, and holding the other end between his finger and thumb, drew the thread tight as he made it slant downwards till

it touched the surface of the fruit at a little distance from the pin, thus :



"Now, boy," continued the old sailor, "the pin at the top of the orange shall be you yourself, and the silk shall represent a ray of light coming to your eye from that part of the little globe where the thread just touches the rind. And the way you see distant objects, remember, Owen, is simply by such threads, or rays of light reflected from them, and entering your pupil. But, as the rays always proceed in a right line, it's plain that all such parts of our little globe here as lie below where

the silk touches its surface would be invisible to you, since no straight line, or ray coming from *them*, could possibly reach the eye. Well, boy, we'll suppose Mr. Pin to turn his head round and look in another direction. But still he would be able to see no farther than before, and for the same reason—no rays could possibly enter the eye from any point of the surface below that touched by the silk; and as all the points so touched are equally far removed from the head of the pin, it follows that the line bounding the sight in the distance, would appear to form a perfect circle. Look you, youngster," continued the old man. "While I move the thread gently round the orange, you trace, with the point of one of the steel pens yonder, the figure described on it by the silk just at the point where it grazes its surface."

"I declare it's a perfect ring, sir," cried Owen, just as he was putting the last scratch to the circle with the dry point of the pen, and when the mark was made it was like that indicated by the dotted line in the engraving.

"Yes, lad; that ring now is the pin-head's horizon, and if we shifted the pin's place to any other part of the little globe, we should find that the visible boundary-line would be invariably of the same figure. For you see, youngster, the horizon—or, in other words, the limit to the sight—results from the roundness of the earth, and does not pro-

ceed from any inability on our parts to see objects at a greater distance, or from there being any haze or mist in the offing to screen them from the eye. This we know to be the case, because objects can be seen perfectly well beyond the horizon—or 'offing,' as we call it at sea—provided they are raised above the level of the ocean. Get another pin, Owen, and do you stick it in the orange just a little way below the point where the silk touches the rind, so that the head of it may stand just above the line formed by the silk. Do you see, boy?" inquired the Captain, when Owen had inserted the pin as here shown.

"A ray of light could now reach the eye from the distant pin-head, and if we supposed this to be the mast-head of a vessel, why we should see it looming above the horizon; and then, as it came nearer to us, we should perceive more and more of the masts and sails, precisely in the same manner as we shall see more of the stem of the pin, if we move it closer to the point where the silk touches the surface of the orange."

The lad shifted the pin to the place represented by the dotted line in the preceding engraving, saying, as he thrust it in, "I see, sir, just now, the thread came close up to the pin's head, and this time there's about half the stem above it."

"Well," returned the old sailor, "you've only to think that thread a ray of light, youngster, to understand how any object on a line with it, or above it, could be seen by a person similarly situated to the pin, and how all things below it would be hidden from his sight, so that it would be only when the object reached the point where the silk touches the orange, that it would be rendered wholly visible. If, however, the pin at the top be made higher than it is at present, we shall find the silk will touch the orange at a more distant point; and if we raise the top pin so that the thread grazes the surface just at the point where the other pin stands, we shall perceive that the visible boundary

will be thus extended,* and the whole of the objects that we could see only in part before, will thus be brought into view without shifting its place. So it is found with ships in the offing at sea; for on going to the mast-head we see more of distant vessels than is visible from the deck, and often the whole of their hulls can be distinguished from aloft, when only the tops'ils could be seen from below."

"I think I needn't trouble you, sir, to tell me any more about the shape of the earth," said Owen; "for I can see now that it can be nothing else than a globe, as you say."

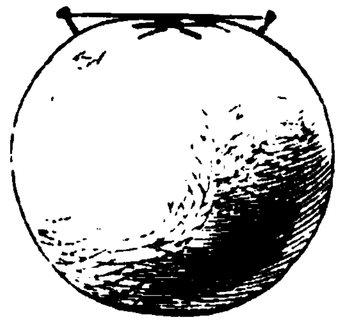
"Very well, lad," replied Captain Jones; "then as we've settled the figure of the earth, we'll now proceed to ascertain the size of it."

"Oh, yes, sir, I shall like that," interrupted the boy, "because you told me yesterday you'd show me the way to find out how many miles it was through the earth, though no one had ever been to the middle of it."

"So I did, youngster, and now we'll set to work to see how we can measure it," proceeded the sailor; "but for this we shall need the orange again, and these two pins that we have stuck in it already will just do for what we want, only we'll make the bit

* See the dotted lines in the engraving at page 261.

of silk which is tied to one of them, fast to the other as well,—in this manner, lad.



"There, Owen, we'll suppose the two pins to be two rocks—or whatever you may please to call them—with the tops just visible to one another over the edge of the horizon, which you know would be where the thread touches the orange, halfway between them. Well, it has been found by observation, that two such points, each 10 feet above the surface of the earth, cease to be visible from one another, over still water, and in ordinary weather, at a distance of about 8 miles; so that you see, the horizon which is halfway between the points, would be just 4 miles distant from either of them. Consequently we have given us for a guide in our reckoning half the length of the arc,—that is to say, half the portion of the circle between the two points—as well as the heights of the points themselves. This is quite sufficient to enable us to find out the length across the entire circle, without going either through or round it; as indeed you'll know when you learn how to measure angles and 'secants' and 'tangents,' lad. For it comes out by

calculation, that *the length across the earth is as many times greater than the distance of the horizon, as that distance is greater than the height of the place of observation.* Accordingly, let us see how many times the distance of the horizon, in the case we have just mentioned, was greater than the height of the places of observation. The distance of the horizon, you remember, was 4 miles, and the height of the places of observation 10 feet. Therefore the length across the earth must be just as many times greater than 4 miles as 4 miles is greater than 10 feet. Well, in 4 miles there are 21,120 feet; so this is 2112 times greater than 10 feet, and 2112 times 4 miles, are 8448 miles—or say in round numbers, 8000 miles. Consequently this, with a slight allowance for the errors of observation, we may consider to be the actual length of the distance through the earth. You see then, lad, it's quite possible to measure the earth without going through it, or round it either."

"I can't make out how you do it, sir," replied the boy; "though it seems to me to be something like the way father tells how much timber there is in a tree before it is cut down. But *is* the earth, Captain Jones, so big as to be 8000 miles through?"

"Yes, Owen, very near upon it," responded the old man; "it's nearly as many miles through as there are days in 22 years."

"Dear, dear," cried the lad, "that *is* a length! A

mile's a good distance I know, and to think of so many coming one after another, like the days in the number of years you mentioned! Why, there would seem to be no end to it."

"Very right, lad," added the Captain; "but even this gives us scarcely any notion of the size of the earth. The mountains and valleys, and abysses, that appear to us to make huge lumps and pits on its surface, are no bigger in comparison with the whole of it than the little specks and pores you see here on the rind of this orange."

"Oh! but Captain Jones," exclaimed the half incredulous boy, "the Garth, on the other side of the river, appears to me to take up a good bit of the earth, and I've heard father say that Snowdon is much bigger even than that."

"Yes, youngster," said the old man, smiling at the lad's simplicity, "and there are mountains again much higher than Snowdon. Still the highest peak in the world is only 5 miles straight up above the ground; and 8000 miles divided by 5, gives us 1600; so that you see the loftiest mountain is only the 1600th part of the earth's diameter. Now if you were to get a ball 16 inches across,—and that's a good big one, remember, for it's about as large round as the dial to a church clock,—such a mountain would be represented on such a ball by a little dot of cartridge-paper, only 100th of an inch in thickness."

"Well, I *never* could have believed it, sir," said the little fellow, jerking his head, "if you hadn't told me so."

"The figures alone, youngster, if you were to calculate them yourself," replied the sailor, "would convince you of the truth of what I say. The deepest mine, moreover," he continued, "does not go half a mile down into the ground, and this is only the 16,000th part of the entire thickness of the earth. So on a 16 inch sphere, a scratch that the thinnest fibre of cotton wool, 1000th of an inch in thickness, would lie in, would be sufficient to show such an excavation. The highest hills would be indicated in proper proportions on such a globe by mere particles of dust; and the whole of the land, with its cliffs that appear to us to tower above the level of the sea, would be, relatively, no thicker than a piece of thin writing paper; while the sea itself—whose greatest depth does not exceed that of the highest lands—would be duly represented on our little model world by the mere film of liquid that would be left by a wet brush drawn over it; and the entire atmosphere above us—which is calculated to extend about 80 miles high—would be fairly typified by an outer case of glass the 6th of an inch in thickness, and this is not more than the downy skin of a peach, in comparison with the size of the fruit it envelops."

"Bless me!" cried the little fellow at the con-

clusion of the comparison, "what a monster of a ball it must be to make all those things that look to us so big, appear so very small."

"Ay, ay, *that* it must, Owen," added the Captain, delighted with the wonder he had excited in his little pupil. "Why a man six feet high—and that's half a head taller than your father is—would be only the 7,000,000th part of the earth's diameter; and if we had to show such an one on our 16 inch globe, we could find no insect small enough to represent so insignificant a creature; a gnat's wing, which is only 100,000th part of an inch thick, would be four times too gross to give his proper proportions."

CHAPTER X

THE BOY AND HIS ORANGE WORLD.

"We have measured the earth, boy," continued the Captain at their next chat, when he had been once more reminded as to the point where he had left off, "but very roughly as yet, for the method we used is by no means an exact one. The portion of the surface dealt with on such occasions, you see, is so small that the least error becomes greatly exaggerated in the gross result; therefore we must consider the dimensions arrived at by those means only as a slight approach to the truth. The length of space that the observations extended over, you will remember, Owen, amounted merely to 4 miles, and this is but the 6250th part of the entire circumference of the earth; accordingly when we seek to infer the size of the whole by so small a fragment of its surface, it is about the same as if we endeavoured to come at the size of our 16 inch globe by measuring the curvature of the 390th part of an inch upon it."

"Oh, if that's the case," exclaimed the disappointed little fellow, "perhaps what you've been telling me is only a mistake, after all."

The old sailor replied, "Nay, nay, it isn't so bad as that, though it's not sufficiently accurate to be of any real use to us; and you see, my little man, we can measure but little bits of the earth's surface at best. We cannot grasp the whole of it, you know, nor go so far away as to see it all at once; so all we can do is to creep about its surface, and apply our little measures to small parts of it in different places, and then make up by reasoning for the defect of our physical powers. Consequently it behoves us to be most accurate in the dimensions of the portions that we *do* measure, for an error of a mile in a degree—since a degree is the 360th part of a circle—becomes magnified into 360 miles in the circumference, and 115 miles in the diameter. Still, as a degree is not more than 70 miles in length it is quite possible, now a days, to ascertain the precise extent of such a portion of the earth's surface within a very few feet, or indeed inches."

"But what is a degree, as you call it, sir?" inquired the boy.

"A degree is the 360th part of any circle—large as well as small," answered the Captain.

"Then, sir," said Owen, "how could the people who were measuring the earth know when they had

finished a 360th part of it, unless they first knew the length of the whole?"

"That's just what we want to settle, my little sharp one," the old man returned; "and what's more, how are the people to be certain they are measuring in a straight line along the earth? for both of these conditions are necessary for accurate measurement."

"That I'm sure I can't tell; and I don't see how any body else is to find it out either," said the lad.

"Let us see, youngster," responded Captain Jones. "Well, in the first place, the earth has no land-marks on it to point out the degrees, nor any traces inscribed on its surface to direct us exactly in a straight course. Nor will the compass help us in such a case, for though that does well enough as a guide for the mariner, it is too subject to variations to be depended upon where extreme accuracy is required. We must, therefore, since we can find nothing on the earth to aid us, turn to the heavens, and see if, among the natural marks up there, that are as permanent as the earth itself, we can find any that will serve us as beacon-lights to mark our whereabouts on the globe. But before doing this, let us parcel out the earth itself into certain equal portions, and see what we can learn from that. Now, as we know the earth to be round like a ball, we can divide it in the middle into two parts, each of the same size, and the line which thus divides it is called the '*equator*,'

or equalizer, simply because the parts on either side of it are of like dimensions. But let us have our little model world again, boy: do you get the orange and cut a small furrow in the rind round it, as nearly in the middle as you can judge."

"Will that do, sir?" asked the lad, when he had scored the orange round as directed.

"Oh, yes," returned the old man, "quite well enough for what we want, for if the parts on each side of the line are not exactly equal, why we'll imagine them to be so, and that will be all the same. Well, this point where the stalk has been, you see," he continued, as he placed his finger on the top of the orange, "we'll call one of the poles,—the North Pole it shall be,—and the little speck there at the bottom, directly opposite to the other, shall be the South Pole; and take my word for it, we'll have a beautiful little world in a minute or two."

Then some more circles were scored round the orange, so as to be parallel with the equator. These, the Captain explained to the boy, formed what were styled "parallels of latitude;" and he told him, moreover, that all countries situated on the same parallel were the same distance from the equator and the pole. Then laying his finger between the fifth and sixth lines north of the equator, he pointed out to the boy how between these parallels lay England in one part; in another part Sweden and Prussia; and after that a portion of Russia; next to this came Kamskatcha; and then a bit of North America;

and as he named the several countries he amused the boy with curious rambling stories about the people in each of them.

Presently Owen was at work again cutting a flat broadish ring out of a piece of stout card-board under the captain's guidance, and making the aperture in the middle of it large enough to admit of the orange passing freely through it. This finished, and the circle portioned out into spaces of 10 degrees each, the old sailor, who grew almost as pleased with the contrivance as the boy himself, bade Owen pass a long pin through the edge of the ring, so that it might run between the card-board, from the outside to the inside of it, and have the point standing out so as to serve as the axis for the orange to turn upon. When this was done he directed the boy to pass another pin through the card-board in the same manner as the first, and directly opposite to it.

"And what are we to call this pasteboard circle, sir?" said the little fellow, as he proceeded with the work.

"Why, that's what's termed a meridian," was the answer. "It's so called because *meridian* in Latin signifies *mid-day*, and that's the line the sun always crosses at noon; so that there are as many different meridians as there are different places round the globe. Now it's along that meridian line degrees of latitude are measured. Latitude means breadth, that is to say, it's the breadth of the world from the equator to the poles—for that's the way the latitude, or breadth, is always measured."

"And I suppose, sir, as there's breadth to the world there's length as well?" remarked the pupil.

"Yes, youngster; and as the *breadth* is called *latitude*, the *length* is called *longitude*. The length of a thing you know extends directly across the breadth of it, and so the longitude is measured at right angles, as we say, to the latitude. But we wont confuse ourselves with thinking about the longitude at present. The *latitude* is what we want to measure, and so we'll keep to that. Well! a degree, I told you, is the 360th part of a circle—no matter whether the circle be large or small—whether it be a line running round this orange, or round the earth itself, or even the sphere of the heavens—it is considered to be divided into 360 equal parts, and each of these parts is termed a degree. But to make the divisions on our little globe plainer, we have divided the meridian into only 36 parts, so that each of those parts will stand for 10 degrees. Do you go to work at that, Owen."

Next the Captain told Owen to form a second card-board ring, with the same sized aperture, but doubly as broad as the previous one, and to cut two slits in it, one on each side and extending half across it from the inner edge. As soon as these were completed the orange was fixed by means of the pins within the first ring, and then this, with the orange in the middle, was passed down through the slits into the second ring; so that the one stood

at right angles to the other, and the orange in the centre of the two.

The next step was to hunt for something that would serve as a stand for the tiny world. After some little time the glass sugar-basin was thought of, and, having been emptied of its contents, a cork was placed at the bottom (as a support for the card-board meridian), and a slit cut down it, so that the meridian might pass freely through it when turned round.

It did not take long to arrange the puny globe on its glass-stand, and when the work was all done the little orange-world had this appearance—

"Doesn't it look pretty, Captain Jones!" cried Owen, as he drew a few paces back and twisted his head from one side to the other, in order to have a better view of the whole object.

"Ay, ay," responded the sailor, "it's a little fairy world; and by-and-by, when we've finished with it, you, like a great ogre, can gobble it up."

The little fellow laughed outright, as he said, "Wont it be funny, sir, to eat the earth?"

"Yes; and very pleasant eating you'll find it, I dare say. I shouldn't wonder, now, but what you'd like to have a world to devour every day, just as a relish after your dinner—you horrible little Fee-fo-fum, you! But come, youngster, it isn't time to 'pipe all hands to mischief' just yet—we must wait till the 'dog-watches' for that. So, where were we? let me see! dear-o-me! where were we?"

"You were going to tell me about the latitude, sir," interposed the boy.

"Oh! I know!" proceeded the volunteer schoolmaster. "Well, the broad ring resting on the sugar-basin there, stands for the horizon, Owen—supposing you to be able to see half over the earth at once. Now the horizon has its poles as well as the earth itself. These are situated right up over head and right down under foot; and no matter whereabouts on the earth we may be, as the horizon shifts wher-

ever we shift, and we're always in the centre of it, why the poles of it, as I said before, are always straight up above and straight down below. The two poles of the horizon are called the 'Zenith' and 'Nadir;' the Zenith being the point of the sky directly over us, while the Nadir, or *nether** pole, is the point of the sky directly under us. These two poles therefore are exactly 90 degrees, or a quarter of a circle, distant from every part of the horizon. Now," continued the sailor, "we've got our little world right on end, and supposing you to be on the top of it, its north pole would be directly in a line with your zenith, or the upper pole of your horizon; and its south pole in a line with the nadir, or lower pole of your horizon. Then it's plain that you'd be in 90 degrees latitude; that is to say you'd be 90 degrees distant from any part of the equator; and the pole of the earth would be 90 degrees distant from any part of the horizon. You see that, don't you, lad?"

"Oh yes, sir; there's the figure 90 standing right up at the top, and the equator is exactly level with the horizon here," answered the lad.

"Well," the Captain went on, "let us twist the globe round one quarter of the circle, so that the poles may be level with the horizon, and the equator perpendicular to it—like this, my little man;" and as

* Nether and Nadir are etymologically the same words.

he said so, the old man shifted the little world into the position here shown—

"Now what do we find?" inquired Captain Jones. "Why, supposing you to be standing on the equator, midway between the poles, you'd be in *no* latitude, since the equator is the point where the reckoning starts from, and the poles of the earth would be *no* height above the horizon, because, you see, they're exactly level with it. There, look at it well, youngster, and convince yourself of the fact."

"Yes, I see," observed Owen, as he examined the model; "there's the 0 mark up at top, and so, of course, if I was there I should be in no latitude; and

here are the two pins for the poles right down on the card-board ring which stands for the horizon, and so the poles can't be any height above it."

"Very good, my man," added the teacher. "Well, you know, in the first case you were in 90 degrees latitude, and the poles of the earth were 90 degrees high, and this time you are in *no* latitude and the poles are *no* height."

"Does it then, sir, always follow that the latitude is the same as the height of the earth's poles above the horizon?" was the boy's inquiry.

"Let us see," was the old man's reply. "We'll shift the globe once more, and get the poles into this position—

"Now, you perceive," continued the sailor, "you would be in 30 degrees latitude; for that is the figure which is in a line with the zenith at present; and, if you look, you will find that the poles of the earth are exactly the same number of degrees above the horizon."

"Bless me! yes, so they are, I declare!" exclaimed the boy, as he gazed at the figures to assure himself of the fact. "Dear! dear! how very odd! Then it *is* so, sir; *the latitude of a place is always the same as the height of the pole of the earth above the horizon.*"

"You're quite right, lad," the sailor replied; "and you'll think it just as strange, I dare say, when I tell you that '*the complement of the latitude,*' *is invariably equal to the height of the equator above the horizon.*"

"What does the complement of the latitude mean, if you please, sir?" asked Owen.

"The *complement* of the latitude, boy," answered the Captain, "is the number of degrees required over and above the latitude to *complete* the 90. For instance, we are in 30 degrees latitude on our little globe here, and therefore the complement to that latitude—or the 'co-latitude,' as it's called for shortness sake—would be 60 degrees; since 60 degrees added to 30 make 90. And now, if you look at our little model, you will perceive that the equator, or point where the 0 mark stands, is just 60 degrees above the horizon. The latitude, bear in mind, is measured from the equator to any part

of the earth, and the co-latitude from that part of the earth to the pole."

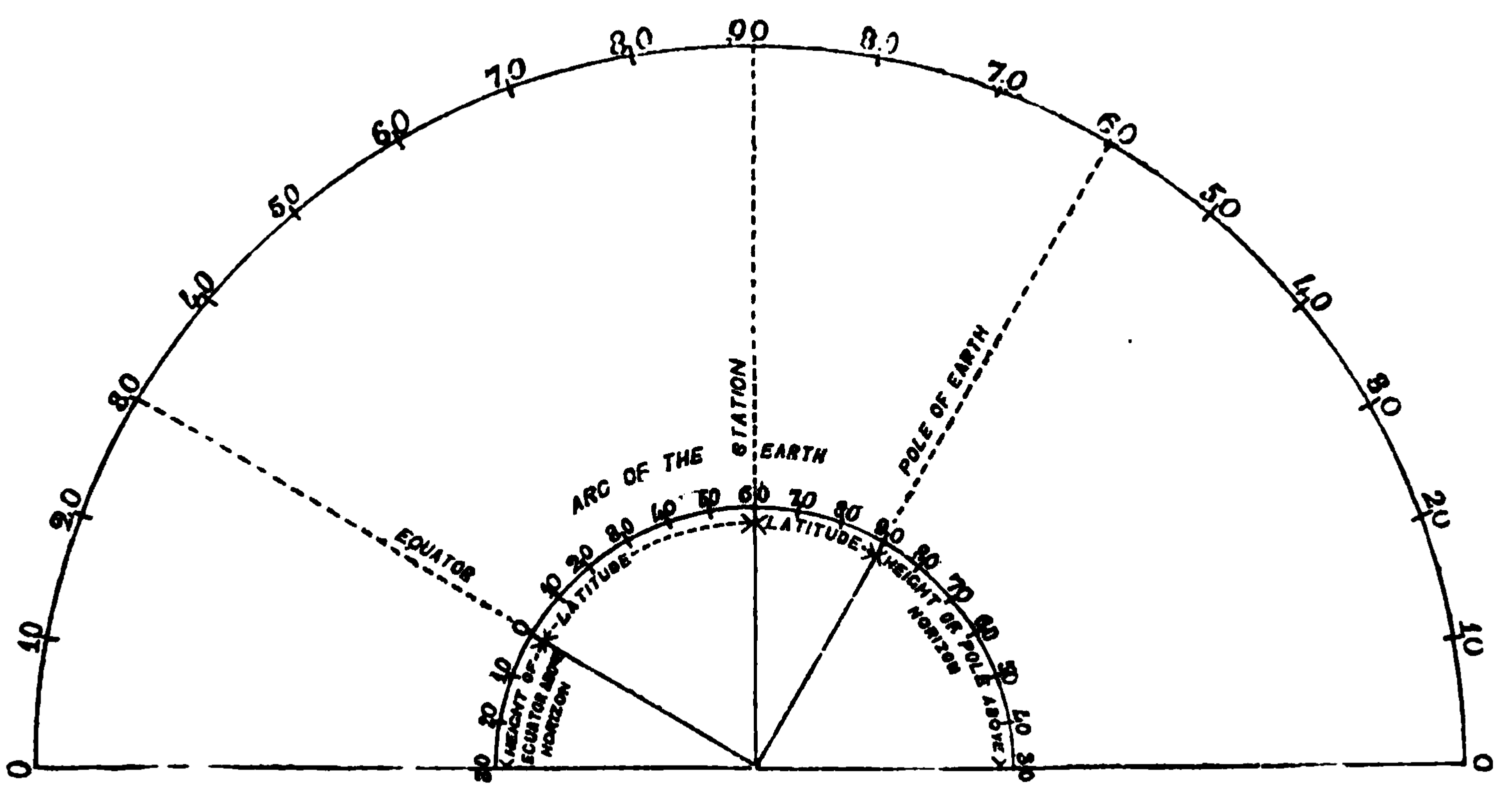
"But, Captain Jones," interrupted the lad, "why is it that the latitude is always the same as the height of the pole above the horizon, and the co-latitude the same as the height of the equator above it?"

"Ah! I thought you'd be at that, Mr. Inquisitive," smiled the old man. "You *must* have the reason for everything. However, to make you understand this, I must get you to do me a little bit of a drawing."

Accordingly, Owen was despatched for the captain's case of mathematical instruments; and, when these were found, the little fellow was shown how to describe, by means of the compasses and graduated arc, the subjoined figure.

ARC OF THE SKY.

Zenith.



"There, my youngster," said the delighted old man, as soon as the diagram was finished, "the upper half circle represents a section of the sky, and the lower half circle a section of the earth, and there are 180 degrees in each. Well, the equator, you know, is at 0 degree on the earth, while the poles are at 90. Now let us suppose you, Owen, to be situated at 60 degrees latitude, then you will have, of course, the upper pole or zenith of the horizon right over your head. But, this zenith point, you observe, divides the arc of the sky into two equal portions, having exactly 90 degrees in each. Then if a line be drawn from the zenith down to the centre of the earth, it will divide the arc of the earth also into two equal portions—each containing 90 degrees as well. Since, then, the equator is 60 degrees from the place we've supposed you to be at, on our little globe here, why the equator must be, at the same time, 30 degrees above the line of the horizon, because that is the number of degrees required to make up the 90 with the arc of the earth on that side of the zenith line. But 30 degrees is exactly the *co-latitude* of that part of the little globe here which we've supposed you to be upon, and therefore the co-latitude—or your distance from the pole—must be exactly equal to the height of the equator above the horizon. On the other hand, your co-latitude being 30 degrees, and there being likewise 90 degrees on the other side of

the zenith line, why the height of the pole above the horizon must be just 60 degrees. But this is your *latitude*, and therefore the height, or altitude of the pole is precisely the same as the latitude of the place."

"I see it now, and I don't think I shall forget it very soon," said Owen, and then he repeated to himself over and over again;—"*The latitude of a place is the same as the height of the pole above the horizon, and the co-latitude the same as the height of the equator above it.*"

Suddenly the boy paused, as a new thought entered his mind, and he exclaimed, "But, Captain Jones, where's the use of knowing all this, unless we can tell how high the pole, or the equator, really is above the horizon? for unless we could find out *that*, we couldn't tell what the latitude was at all."

"You're very right," returned the old man, "and now we are going to see how that's to be done. Well, there's nothing upon the earth that will serve us in this matter; nor can we get outside of it, Owen, to have a peep at the pole or the equator, and so learn how high they stand above our horizon. Besides, even if we could, when we were outside the globe, we should find that our horizon and zenith were no longer the same: and so *that* plan would be of no use to us. Consequently, we must turn to our old friends the stars, and see if we can learn anything from them. Well, you will re-

member I told you the other day that the stars all seemed to be turning round some fixed point in the sky."

"Yes, sir," answered the pupil. "That is, they *seem* to be doing so, though Hugh and I last night couldn't find any such point at all; for every one of the stars we looked at appeared to be on the move."

"Well, we wont mind about that, just now, youngster," said the other, "though there *is* such a point, sure enough, and it isn't any star, either. But, as I was saying, all the stars appear to revolve about some fixed point in the sky; and if you had noticed them long enough last night, lad, you would have found that the circles they described are all inclined to the horizon; that is to say, none of the stars appear in this part of the globe to rise straight up from the earth, nor to sink straight down below it, but to take a slanting course through the heavens, and to revolve as it were *on the slope*—just the same as if you were to tilt a barrel on its end, and make it turn round on its edge, when the hoops about it, you know, would all be seen to circulate slantingly."

"Wouldn't they be like the rings on a peg-top, sir, when it leans on one side as it spins round?" suggested the boy.

"That's just it, my little man," responded the Captain. "But if you were to set out on a long journey towards the south, shall I tell you what would

happen?" (The boy nodded assent.) "Why, the slanting circles that the stars appear to describe here, would get straighter and straighter, until at last, when you reached the equator, you would find that the stars there all rose and set *perpendicularly* to the horizon, and traversed the sky straight from one side to the other—the same as if, instead of tilting the barrel on its end as before, you turned it down and caused it to revolve on its side, when all the hoops, of course, would be seen to run round straight up above the ground."

"How very odd, sir!" exclaimed the boy.

"And what's odder still, youngster," went on the sailor, "you'd have found, as you travelled in this direction to the equator, that the stars *in the extreme south*, which I told you rose here only just above the horizon, and showed themselves but for a few moments, came up higher and higher, and remained visible for a longer time; while those *in the north*, which, as I said before, just grazed the northern horizon, and dipped below it for an instant in this part of the globe, would, as you journeyed on to that part, get to sink deeper and deeper below the earth, and continue invisible for a greater period. Until at length when you reached the line midway between the poles you would perceive that the fixed point in the north part of the sky, which all the stars here appear to revolve round, had sunk so low that, instead of standing *high above the earth* as with

us, it would seem there to be *on a level with the horizon* itself; while the stars immediately round about it, which in these parts *never set*, but revolve continually above the earth, would in those parts perform only half their course above the horizon. Moreover, stars that had *never risen* before to your view, would have sprung up in the south, one after another, as you went on; so that at last you'd discover at the equator that there was another fixed point in the southern quarter of the heavens which the stars revolve about, like that in the north. You'd find, too, that, not only the stars that never rose or never set to you *here*, but every one, indeed, throughout the heavens, would *there* remain for twelve hours visible, and concealed for the same time —each little orb performing half its circle above and half beneath the horizon, and all revolving round two opposite points in the sky that seemed, from such a station, to be on a line with the horizon itself. Then, again, at that point of the globe no part of the heavens would be altogether hidden from your sight, for the upper and lower sky would become visible to you one after the other, and in a night of twelve hours* the whole vault of stars which you first observed above you when the evening drew in, would, by the time the morning came round, have

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* Supposing such a continuance of darkness to be possible at the equator.

been carried down beneath, and the lower vault brought up from below."

"How beautiful it must be to go there," exclaimed Owen, with his eyes riveted on the old man. "I suppose you've seen it often, Captain Jones, when you were at sea?"

"Ay, ay, boy! scores of times," replied the seaman, and he had immediately half a dozen stories about the matter start to the tip of his tongue; remembering, however, the many facts he had still to communicate, the old man dismissed the tales from his mind, saying, "but we must keep our head well up to the course we've laid down, lad, or we shall never reach the port we're bound for. Well, youngster," he continued, "if you were to go on still south'ard past the equator, you would perceive that the fixed point, which the stars in the south were revolving about, would appear to *come up* above the horizon as you went, while the one which the stars went round in the north would be seen *to sink* below the earth and disappear from your view; and when you reached that part of the globe which was just as many degrees removed from the other side of the equator as the place you just started from was distant from this side of it, you would find the whole appearance of the heavens reversed. The stars in the north, which *never set* to you *before*, would *never rise* to you *then*; and those in the south, which *never rose* at the spot you departed

from, would in your new place *never set*, but remain visible all the night through; while the whole of the orbs, instead of coming *straight up* from the horizon, and sinking *straight down* below the earth, and each remaining in sight for exactly twelve hours, as they did at the equator, would once more appear to traverse the heavens in a *slanting* direction; but instead of sloping as before, towards the *south* when they rose, their circles would now be seen to be inclined up towards the *north;* and again, no two of those that rose and set would continue visible for exactly the same period."

"Go on, if you please, sir!" said the youth, more and more delighted with the description of the wonderful changes.

"Then, supposing it were possible for you to continue right on until you reached the south pole itself, you would perceive that the fixed point in the sky, which the southern stars revolved about, kept on *rising higher and higher* in the heavens, and the circles of the stars growing less and less inclined to the horizon as you proceeded; so that at length when you stood on the very pole of the earth, the fixed point in the sky—instead of being *level with the horizon*, as it appeared at the equator, or seeming to be *raised* halfway up the sky, as it did when you were but halfway towards the pole—would be seen, now that you had reached the extremity of the earth, *right over your head;* while the stars about it would

appear to revolve in circuits neither *slanting* nor *perpendicular* to the horizon as formerly, but perfectly *parallel* to it; nor would any of them ever rise or set there, but all would remain for ever revolving sideways above the earth in circles that grew smaller and smaller towards the zenith, like the coils in a bee-hive."

"Oh! I am so much obliged to you, Captain Jones!" exclaimed the enraptured boy; "it makes me feel so happy to know all this! And yet I can't tell why it should, for what good can the stars ever do me?"

"The stars, Owen, have done me many a good turn," retorted the sailor; "they've saved me and my whole crew from shipwreck over and over again. And who can say, boy, but they may be one day the same trusty friends to you? But to keep to our point, lad. Well, if you were to set off from the south pole, where we left you, and come back again to the equator, you would find that the fixed point, which stood right over your head at the southern extremity of the earth, would begin *to sink* again, and the stars to *slant* in their circuits; so that when you arrived at the equator once more, the *two opposite* points in the sky, about which the stars revolve, would again become visible to you, and appear *level* with the northern and southern points of the horizon, while the stars themselves would no longer circulate *sideways* about the earth, but go

straight up over it. Then, as you progressed towards the other pole, the *southern* fixed point would begin to *sink* and the *northern* one to *rise* in the heavens, while the little orbs would be seen once more to take a *slanting* course through the sky but in the *opposite* direction to that which they were observed to move in on the other side of the equator; and at last, when you reached the north pole, you would find the fixed point, which the northern stars revolved about, was *straight* over your head—even as the southern fixed point was when you were at the south pole; and that the stars again *never rose nor set*, but kept on moving continually in circles *parallel* with the horizon. But though the movements of the stars would seem the same at this pole as at the other, you would find on noticing the orbs themselves, and the figures they formed with one another, that *not a star you saw at the opposite extremity of the earth, was to be observed at this end of it;* for while at the south pole you would have seen only the southern half of the sky, at the north pole only the northern part of it would be visible to you, whereas at the equator in the course of twelve hours you would have beheld the two hemispheres — the one succeeded by the other."

"Oh! I see," cried Owen; "we should catch sight of an opposite half of the sky from each of the opposite poles, and see the two one after another at

the equator, just as a bluebottle inside a humming-top would see if he looked up only the upper half of the top spinning sideways about him; and if he looked down only the lower half doing the same thing; but, if he looked towards one of the sides, of course he'd get, as the humming-top spun round, a view of the whole."

"Very nicely explained, youngster," said the old sailor, patting the boy on the back. "And what do you think would happen, Owen," added his teacher, "if you could be suddenly carried from this side of the equator across to the other side of it, and back again immediately to the place you started from? Why, you'd see the two fixed points in the heavens, with all the stars about them, *move up and down* just like two youngsters playing see-saw."

This supposition tickled the boy's fancy, so that he tittered again at the idea of seeing the stars indulge in any such frolics.

"Well," proceeded the Captain, "let us see what we can glean from all this. In the first place, then, we have found that when we're at the north pole the *northern* fixed point of the heavens, which the stars are revolving about, is *straight up over our heads;* when we are at the south pole, the *southern* fixed point stands *over our heads* in like manner; and when we are at the equator, the two fixed points are seen on a *level* with the horizon, and to occupy the northern and southern points of it. Now our

little globe has shown us that when we are standing on the equator the poles of the earth are also on a *level* with the horizon, and when we are on either of the poles themselves that they are *perpendicular* to the horizon; so that if we were at one of the poles and a line were drawn from the opposite pole through the one we were standing upon, and extended on each side to the sky, above and below us, *that* line would touch the zenith and nadir, or upper and lower poles of our horizon—that is to say, the points directly over our head and under our feet. But these points would be also those round which the stars were revolving. And as a similar line drawn through the poles of the earth when we are at the equator—where the poles would be level with the horizon, you know—would if extended to the sky again meet the fixed points of the heavens—(for *they* would be also level with the horizon then)—it is plain that *the two fixed points in the sky round which the stars revolve, must always be in a direct line with the poles of the earth itself.*"

"Why, yes, so they must, indeed, now I come to think of it," said Owen, thoughtfully.

"And that's the reason, my boy," returned the Captain, "why those fixed points in the sky are called the poles of the heavens, or poles of the world if you like."

Here the conversation was suddenly interrupted

by the entrance of the housekeeper with the tray full of plates, glasses, and knives ready to be set for dinner.

As the dame stood with the table-cloth in her hand the old man inquired whether she couldn't give them a few minutes longer; but being informed that thepudding would be "all abroad," as Mrs. Pugh expressed it, and the chicken burnt to a cinder, the Captain said, "Well, Owen, we must clear the decks, and you must come again to-morrow and have some more astronomy and some more pudding."

CHAPTER XI.

HOW PEOPLE TRAVEL WHERE THERE ARE NO ROADS, FIND THEIR WAY WHERE THERE ARE NO SIGN-POSTS, AND KNOW HOW FAR THEY HAVE JOURNEYED WHERE THERE ARE NO MILESTONES.

OWEN was with the Captain early the next morning, when as usual, he had to repeat to the sailor the greater part of their conversation of the previous day, before he could get his oblivious old tutor to remember the precise point where they had left off.

This, however, was at length impressed upon the Captain's mind, when he proceeded to say, "Well, then, first we've found out, you know, that the latitude of a place is just the same number of degrees as the height of the pole of the earth is above the horizon; and secondly, that the poles of the earth are in a

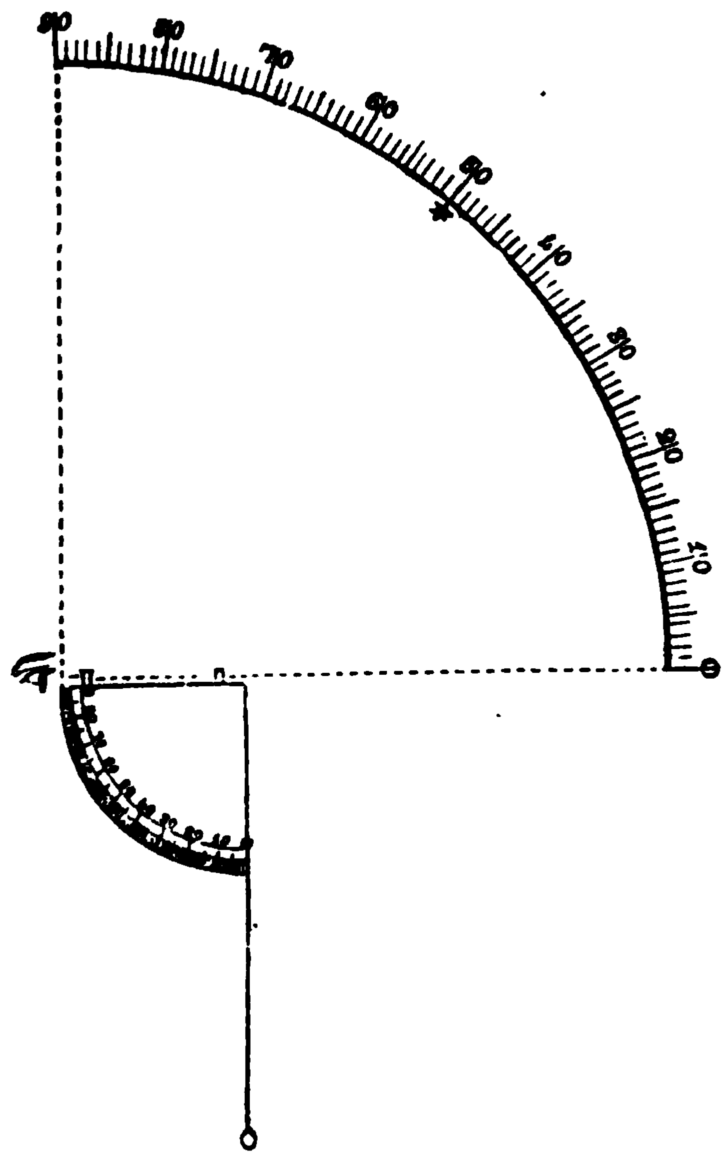
straight line with the poles of the world; we have settled also that a degree is the 360th part of a circle, whether the circle be large or small; consequently, the *latitude of a place, north or south of the equator, must be the same number of degrees as the north or south pole of the heavens appears to be raised above the horizon.* So, you see, we've only to measure how many degrees high the fixed point in the heavens, which the stars revolve about, seems to stand above the horizon, in order to know the latitude of any place we may be in upon the earth."

Owen smiled as he said, "It's all very well, Captain Jones, to say we've *only* to measure this height, but how is that to be done, I should like to know? You can't climb up there and put a tape to it." And the little fellow laughed outright at the absurdity of the notion.

"Why, no, lad," returned the old man, enjoying the apparent difficulty as much as the boy himself; "but there are other ways of measuring besides with a foot-rule, or tape, or yard-sticks. So our next step must be to find out how we can measure the heavens without any such instruments. But to make this quite plain to you, you must do me another drawing."

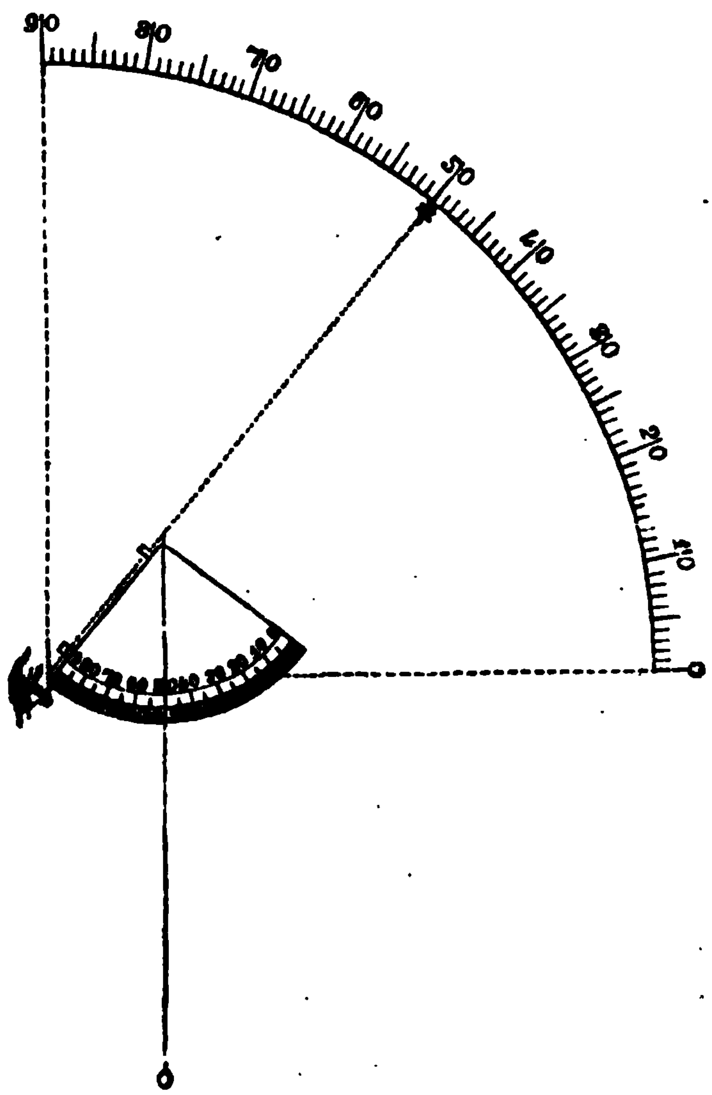
Accordingly, the boy was busy again, with the old sailor at his elbow, showing him how to describe

the following figures by means of the compasses and arc.



"There, now, lad," said the sailor, when the diagrams were finished, "the big arc up above is intended to represent in both drawings a portion of the sky, and we've placed a star there, 50 degrees above the level of the earth, the horizon being shown by the dotted straight line at the bottom of each plan. The height of this star above the horizon is what we are going to measure by means

of what is called a quadrant, which is represented at the corner of both of the drawings. This qua-



drant consists of a piece of board, cut so as to form a quarter of a circle, and graduated round its edge; that is to say, it is divided into 90 degrees there. On one side of the quadrant are placed a couple of little metal plates, with a fine hole in each of them, for the eye to look through, and these are called 'sight-holes;' while, from the centre point of the circle of which the quadrant is the quarter, is suspended a thread with a weight or plummet at the

end of it, so as to cause the line to hang always perpendicular to the horizon. Now suppose, youngster, you want to measure the altitude of the star represented in the drawing. Well, you hold the quadrant level with the horizon, and then, of course, the plumb-line hangs at 0 degrees on the graduated arc. As you slant the upper edge of it with the sight-holes along it 10 degrees above the horizontal line, the other edge of the quadrant passes just 10 degrees beyond the plumb-line, and so on—each degree that you incline the one edge upwards, the other edge is thrown just one degree out of the perpendicular, and the extent of the inclination duly indicated by the plummet; till at last the sight-holes are brought into a direct line with the star whose altitude you wish to ascertain. Immediately the rays from it meet the eye, the plumb-line is held fast; then the number of degrees that it is found to cut, or hang over, on the graduated arc, tells you exactly how many degrees the upper edge of the instrument has been inclined in order to bring the little orb into sight, and this consequently gives you precisely its altitude above the horizon. The star, you perceive, is 50 degrees high, and the plumb-line in the second drawing hangs at 50 degrees on the graduated arc of the quadrant. Do you follow that, Owen?"

"Oh yes, sir," returned the boy, "and I'll make one of those quadrants myself, by and bye. It wont

be very hard to do, will it, sir? Is a quadrant one of the things you used to work with at sea, Captain Jones?"

"Yes, lad," replied the old man, "but mine was rather different, for I made the one I've explained to you as simple as I could, so that you might have no difficulty in understanding it; still the principle is the same as the one I used at sea. Well, now we know that not only is the latitude of any place equal to the altitude of the pole of the earth, and the altitude of the pole of the earth again equal to the altitude of the pole of the heavens, but we know also how to measure the height of any celestial object, and consequently that of the pole of the heavens among the rest."

"Oh! I can make out how you do it, now," cried Owen, "for measuring the height of the pole of the heavens above the horizon tells you the latitude of the place you're in, of course. Isn't it clever of people to find out such things?"

"But wait a while, my little man," interposed the sailor, "we haven't got over all our difficulty yet. If there was a star fixed in the pole of the sky, of course the only thing required would be to measure the altitude of that star in order to get at our latitude; but unfortunately there is no such star to mark the point that all the others revolve about; for you remember I told you that this pole is not a star, nor is there anything at that particular

part of the heavens to enable us to distinguish it from any other point of the sky; it is in fact merely the centre of all the circles, that the stars appear to describe in their course above the earth. So when I call it a pole you mustn't imagine, lad, that there's a long stick up there, as I used to do when I was a boy; nor fancy that the pole of the earth comes out at each end of it, and that the world is made to spin round upon this like a teetotum. The pole of anything, bear in mind, is merely the fixed point or end of the axis on which the thing turns. Well, then, you understand that the pole of the heavens is merely a fixed point that the stars *seem* to revolve about, and the question is how are we to tell exactly where that spot is in the sky, since there's no mark set up there to distinguish it?"

"That's too hard for me to answer," was the boy's reply. "I should never find it out; it would give me the fidgets if I were to try."

"Well, youngster," replied the old Captain, "suppose you wanted to find the centre of a circle, how would you proceed? Why, you'd measure straight across it, wouldn't you? and take the half of the length, which would give you the middle, of course. So you've only to do the same thing with the stars to come at the same result—you've merely to measure the diameter, as it's called, of the circle described by

them as they revolve about the pole of the heavens, to find exactly where that pole is. The star that is usually selected for the purpose of finding the altitude of the celestial pole, is one called the 'pole star,' for it is a very brilliant one, of the second magnitude, and but little more than one degree and a half from the pole of the world itself. Being so near the pole, the pole-star, of course, never sets, and is therefore of great importance to sailors in the northern hemisphere. Now, the pole-star is the last in a group of stars, or constellation, known by the name of the 'Little Bear,' which is easily distinguished by its being formed of seven stars, arranged in the same manner as those in the group or constellation styled the 'Great Bear,' from some fancied resemblance to the shape of that animal."

"But how shall I know where to find those constel—constellations, didn't you call them, sir—in the sky?" inquired Owen.

"Well," replied the sailor, "if you turn yourself towards the north, some fine starry night, and cast your eye up to the heavens at some distance above the horizon, you will perceive four bright stars arranged in the form of almost a square, and three others extending in a bent line from the faintest of these. The three stars represent the tail, and the four form part of the body of the Great Bear; they are all, with the exception of the one

that the tail extends from, of the second magnitude, and therefore easily perceived. Then if you carry your eye along the sky in a direct line with the two stars in the body of the Great Bear that are the farthest from the tail, you will perceive, at some slight distance from them, a cluster of seven other stars, smaller than those of the Great Bear, but arranged in the same manner though in a *reverse direction*; that is to say, the three stars in the tail of the one will point the contrary way to the three stars in the tail of the other. The seven smaller stars constitute the constellation called the 'Little Bear;' the four in the form of a square being the body, and the three extending in a bent line from one of these being the tail—in the same manner as with the Great Bear. Now the last star in the tail of the Little Bear is the brightest of the whole seven,—some of the others being only of the 4th and 5th magnitude—and this is the pole-star. It is always in a line with the two stars in the fore part of the body of the Great Bear, which two stars are consequently called 'the pointers,' because they invariably point towards the pole-star. But to give you a clearer notion of what I mean, I'll get you, Owen, to step into the back-parlour and bring me my atlas, for we shall find there a plan of these two constellations, that I drew when I was a youngster."

The book was soon brought and spread out on

the table before the couple. On the fly-leaf of it was the subjoined diagram.

"There, youngster, you see the Great and Little Bear back to back, and with their tails pointing in opposite directions," said the old man, as he placed his finger on the animals in the drawing; "and in whatever part of their circles they may be, they always maintain that position with regard to one

another. If you look close you'll see that the magnitude of the stars composing the two groups is shown by the number of rays.* Those stars which are of the second magnitude—and they are the largest here given—have six rays to them; those of the third only five, and so on down to those of the fifth magnitude, which are the smallest in the drawing, and have only three. The two foremost stars in the body of the Great Bear—and which, as I said before, are called 'the Pointers'—you will see, by the series of dots extending from them, are in a line with the pole-star. The dotted circles are intended to point out the apparent course of each of these stars round the pole of the heavens, the arrows showing the direction in which the movement seems to take place; and this you can see by the letters at each of the four points is from the east round by the south to the west and thence back by the north to the east again. Now, whether the circle that a star appears to describe in the heavens be large or small, it is completed in one and the same time; that is to say, the star at the

* The magnitude of a star signifies simply its degree of brightness. The brightest stars are said to be of "the *first* magnitude;" those which fall so far short of the first degree of brightness as to make a marked distinction are said to be of "the *second* magnitude," and so on down to the sixth or seventh, which comprise the smallest stars visible to the naked eye in the clearest night. Those beyond the latter magnitude are termed "*telescopic* stars." The smallest stars are supposed to be the most distant.

tip of the tail of the Great Bear, and which you perceive is the farthest in the drawing from the centre or pole of the heavens, would take no longer to travel round, from the point where it now is, back again to the same point, than would the star at the tip of the tail of the Little Bear, and which you see is the nearest of all to the centre. So, although the pole-star has a much less space to pass through, in its apparent revolution round the pole, it seems to travel proportionately slower, and consequently completes its circuit in precisely the same time as the most distant stars. The circles described by the stars round the celestial pole are called 'the diurnal circles,' because they appear to be completed in exactly one star-day, which you remember is just upon 23 hours 56 minutes of a mean solar or clock-day."

"Ah! this makes what you said to me about time a great deal plainer than it was before, sir," exclaimed the little fellow.

"I dare say, youngster; but we can't learn all at once, you know," returned his tutor friend. "Well, now we want to measure the height of the pole by means of the pole-star. If you look at the drawing again you'll see a line running down it straight from the north to the south point. This is what's called the 'celestial meridian;' that is to say, it is the line which divides the vault of the heavens into two equal parts, one on the east, the other on the

west. This line extends directly north and south, passing through the zenith or point immediately overhead, and through the poles of the heavens as well. Well it's on this meridian line that all stars attain their greatest and least altitudes in the course of their apparent revolutions round the pole. For instance, Owen, if you look at the drawing once more, you will see that the pole-star is in the *nearest* position which it could possibly reach to the north. This position, therefore, would be that of its *least* altitude above the horizon, and when it reached the opposite point in its circle, it would, of course, be the *farthest* away from the north, and therefore at its *greatest* altitude."

"So I can see it would, sir," remarked the boy.

"Well, let us suppose that the altitude of the pole-star is found to be, when measured by the quadrant at the moment when it no longer appears to approach the horizon—that is to say, at the period of its *least* elevation—50 degrees. Then let us suppose again that at the period of its *greatest* elevation,—which would be about two minutes short of twelve hours after its least—it was found, at the precise moment when it ceased to recede from the horizon, to be exactly 53 degrees high. Now, since the star was 50 degrees high at its *least* altitude, and 53 degrees at its *greatest*, it is plain that the difference between these figures—which is 3 degrees—must be exactly the length across the circle that

it described in the heavens. Then halving this difference, we have 1½ degrees for the distance of the centre point.* Then adding this 1½ degree to the 50 degrees—which was the extent of the least altitude—or subtracting the 1½ degree from the 53 degrees, which was the extent of its greatest—we have 51½ degrees for the altitude of the centre point, about which the star appears to revolve, or in other words the altitude of the north pole of the heavens itself. Consequently, this would be the north latitude of the place where the observation was made; that is to say, the place would be precisely 51½ degrees distant from the equator on the north side of it, and that is, within a fraction, the latitude of London."

"Oh! thank you, Captain Jones; you've made it so plain to me," said the boy, "that I *do* think when I've made my quadrant I shall be able to measure the height of the pole of the heavens and the earth, all by myself. I wish I'd got the quadrant ready now; for it looks as if it would be nice and starry to-night, and then I'd soon find out the pole-star; for I'm sure I should know where it was, after what you have shown me about the Great and the Little Bear. But there are no real bears up in the sky, I suppose, sir?"

* The distance of the pole-star from the pole of the heavens, is precisely 1 degree and 41 minutes, but it is here made 1½ degree for the sake of simplifying the calculation.

The old man smiled at the boy's simplicity, as he said, "No, no, lad; they are no more real bears than they are real castles and mountains that you see in the fire sometimes. The ancient shepherds, who were the first astronomers, fancied as they lay out in the fields at night, tending their flocks, and gazing at the stars the while, that the figures formed by the different groups of stars were like bears, and swans, and eagles, and fishes, and serpents, and all kinds of strange things; so they called these groups of stars, or constellations, after the name of the creatures they imagined them to resemble. Perhaps this was done as a means to impress the figures formed by the stars on the memory, and so to know their places among one another easier than they could otherwise have done."

"Yes, indeed, sir, and a very good way it seems to me," remarked the boy; "for I'm sure I shall be able to remember the figure of that Big and Little Bear much better than if you had told me they were two groups of seven stars in the form of a square with a bent line running out from one corner."

"I'll be bound you will, my little fellow," answered the sailor. "Well, Owen," continued the old man, "we know how to measure the altitude of the pole by the pole-star. But, to do this, we require two observations at very nearly twelve hours apart, and it is seldom that the night admits of this being done; so we must find out some

readier way of learning whereabouts we are upon the earth. For if we couldn't ascertain *that*, lad, by some means which we could avail ourselves of every day, how could ships be navigated on the high sea, where there are no roads, nor milestones, nor sign-posts, to tell us which way we are going, or how far we have travelled—nothing, indeed, in the vast desert of the ocean to mark one spot from the other. In such a position therefore, we can only look to the heavens to guide us. Now, you'll remember we found out that there are two ways of ascertaining the latitude of any place we are in; one is, that such latitude (or, what is the same thing, our distance from the equator,) is equal to the height of the pole of the earth above the horizon; and the other, that the co-latitude (or our distance from the pole of the earth,) is equal to the height of the equator above the horizon. Accordingly it's immaterial which of these points we measure our distance from, since the result in both cases must be the same."

"Yes, sir, you explained that to me before," said the boy.

"Let us see, then, by what means we can find out how high the equator appears above the horizon in different parts of the earth," proceeded the old sailor. "Well, as the poles of the earth are in a line with the poles of the heavens, it is plain if the earth were cut right through at the equator, and a large flat circle placed between the two halves of it,

that circle would, (if it were large enough to reach to the sky,) exactly divide the heavens into two equal portions, as the equator does the earth itself. The ring of stars that would be in a line with the circumference of this immense flat circle, is what is called by astronomers the 'equinoctial line,' and this is always precisely level with the equator, in the same manner as the poles of the heavens are always in a line with the poles of the earth. Well, it is found that the sun, in his apparent course through the stars every year, takes a slanting direction with regard to this equinoctial line, which he crosses twice in the twelvemonth. But let me see, how can I give you a clearer notion of all this?" And the old man shut his eyes, and kept on mumbling various plans to himself.

Presently he cried, "Oh! I have it. That old glass globe I used to keep the gold fish in till they died, will do famously. You get it down from the top of the china cupboard."

"There, put it on the table, Owen," continued the old man, when the boy had mounted a chair and reached it from the shelf; "and now you must fill the globe half up with water."

This did not take long to do, and when the vessel was half filled, Owen, at the old man's direction, got a plum from the sideboard, and dropped it into the centre of the globe.

"We've got another little world now, you see,

lad," exclaimed the Captain, pointing to the plum. "And we'll suppose the surface of the water to be on a level with the equator, or middle of the plum, and the place where the stalk has been shall be the pole of our little world as before. Then, as the fish-globe stands for the sky, the line where the top of the water touches the glass all round the sphere will represent the equinoctial. Well, if you tie a bit of thread round the outside of the glass, so that it shall slant a little above the level of the water on one side of the sphere, and a little below the level on the other side, then that thread will give you a tolerable notion of the ecliptic, or line that the sun seems to travel along in his apparent course through the stars every year."

The thread was soon fastened round the glass sphere as directed, and in the manner here shown.

"The points where the thread or line of the ecliptic cuts the edge of the water which stands for

the equinoctial line," the old man began, when the little model was complete, "are called the equinoxes; the one to the east being termed the vernal (or spring) equinox, and the other, on the west, the autumnal equinox. At these points the sun is on a level with the equator, and consequently has no declination whatever. Then if we suppose the sun, in his apparent yearly course among the stars to proceed from E, the vernal equinox, where he is on the 21st of March every year, and to travel, along the line indicated by the thread, round the glass sphere, you will perceive that as he journeys on, day after day, he will slant away to the north of the equinoctial line, and get farther and farther from it, until he reaches (on the 21st of June) what is termed the 'summer solstice,' and then his distance from the equinoctial will be 23½ degrees, or in astronomical language, the sun will have attained his 'greatest northern declination.' After this he will begin to slope back to the equinoctial, getting nearer and nearer to the level of the equator, until he gains the western point, W, or autumnal equinox, which he does about the 23rd of September, and then he will, once more, be in a line with it, or in other words, the sun will for the second time in the year have no declination whatever. Then passing the autumnal equinox, his southern declination will commence, and this will increase day after day until he reaches 'the winter

solstice,'* on the 22nd of December, when it will be at its highest point, and the sun precisely as many degrees south of the equinoctial line as it was north of it at the summer solstice six months before. Leaving this point he will again draw nearer and nearer to the level of the equator, until he reaches again the vernal or spring equinox, and then he will once more have no declination whatever."

As the old man entered into the above explanation he drew his finger round the sphere so as to point out to the boy the direction of the sun's apparent path through the stars every year.

"The thread round the glass globe has made the matter much plainer to me, sir," said Owen; "and I suppose I am to fancy there are stars all over the glass sphere, as you call it, and that your finger was the sun passing through them?"

"Now," the Captain went on, "I think we understand this matter quite well enough to be able to comprehend how it's possible to find out the latitude of a place by the altitude of the sun. You have only to bear in mind, lad, that what is meant by the sun's northern or southern declination is simply its distance north or south of the equinoctial line; and as the equinoctial line is, as I have shown you here, always on a level with the equator, why the sun's declination expressed in degrees, is merely the

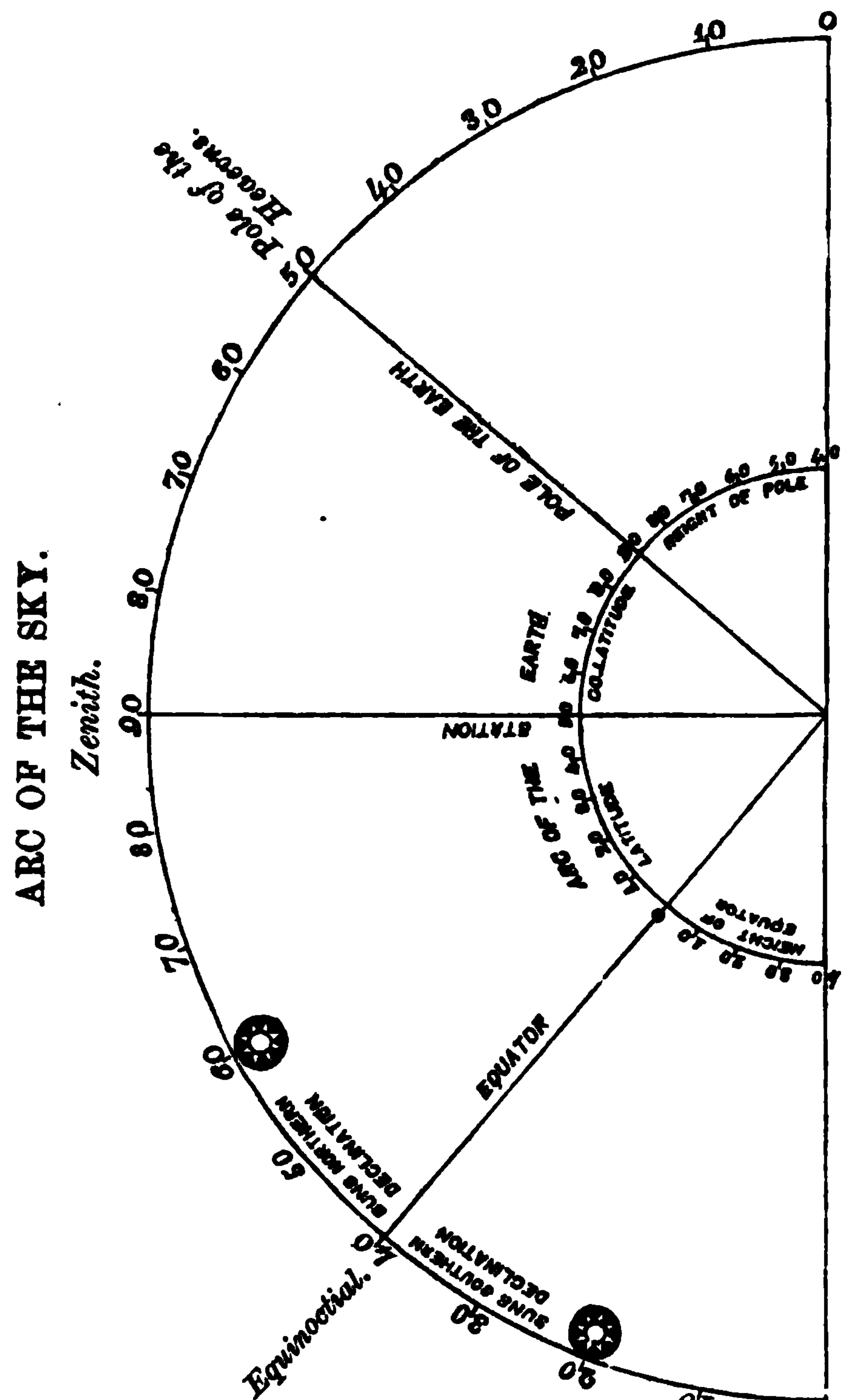
* Indicated by the place where the thread is tied; the point of the summer solstice being supposed to be directly opposite to this.

number of degrees that he is above or below the level of the equator itself."

"I shall take care to remember that," said Owen.

"Now, my lad, get the compasses and do me another diagram as I direct you."

The boy did as he was bidden, and the following plan was the result.



"Well, Owen," said the Captain, "we'll imagine you to be standing there, right under the zenith, and you want to find out how high the equator is above the level of the horizon. Then a little before 12 o'clock you take your quadrant and you measure the height of the sun above the horizon, just at the moment when he appears to cease to ascend in the heavens, and that of course will give you his greatest altitude. Now let us say that you find this to be precisely 20 degrees, as represented in the drawing, then that amount *added* to the sun's declination, or *subtracted* from it—according as he is *north* or *south* of the equinoctial at the time of your making the observation—will give you the height of the equinoctial line, and consequently that of the equator above the horizon. Well, there are tables published which tell the amount of the sun's declination for every day in the year, so you turn to these and find, maybe, that on the day you have measured the sun's altitude, his declination is then 20 degrees *south* of the equinoctial. So you *add* this to his meridian altitude, which was 20 degrees, you remember, and thus have 40 degrees for the height of the equator above the level of the horizon. Then, as the height of the equator is equal to the co-latitude of the place you are in, and the co-latitude of any place is merely its distance from the pole of the earth, you thus find out that you are 40 degrees removed *from the north pole.* And since the

pole itself is 90 degrees from the equator, it is plain that if you subtract the 40 from the 90 you will have 50 degrees for your latitude, or *distance north of the equator itself.* Or let us imagine on the other hand, lad, that you find the meridian altitude of the sun at another period of the year to be 60 degrees, and that his declination, as given in the tables for the day you made your observation, is 20 degrees *north* of the equator; then, *subtracting* that amount from the 60 degrees, you have again 40 degrees for the height of the equinoctial line; and since this is, as I said before, the same as the height of the equator, you have only to subtract it from 90 degrees in order to find the latitude of the place you're in."

"Oh! isn't it nice and plain now, sir?" cried the boy. "And that's the way you used to do it at sea, I suppose?"

"Ay, ay, youngster," answered the sailor; "every day a little before twelve, there we were on the quarter-deck, with our quadrants in our hands, and spying away at the sun, until we found he had got to his highest point in the heavens, and then we used to *make* it twelve o'clock, or 'eight bells,' as we say at sea."

"And so you found out where you were!" exclaimed Owen, delighted that he could now understand how it was possible to ascertain the place of a vessel where there were no marks to distinguish one

spot from another. "How clever sailors must be, Captain Jones!"

"Nay, nay," returned the old man, "sailors didn't make the discovery, remember—for it was astronomers who taught them how to use the sun and stars as beacon-lights in their course; and though the little luminous specks that spangle the heavens at night-time seem to the uneducated eye to be as useless as will-o'-the wisps, still had the sky above us been one blank black dome we should never have been able to navigate the seas out of sight of land, but could only have crept timidly along the coast, and have remained not only estranged from other nations, but deprived of many comforts that we now derive from foreign countries. So when you drink your tea, lad, that has been brought for you from the other side of the globe, and sweeten it with sugar that has been shipped from the Western Indies, you may thank the little stars above you for it all."

"Oh! now I see, sir, that the stars are of great good to us," said the little fellow, thoughtfully.

"Yes, Owen," added the sailor, "and when you come to know more about them, you will see that they are the *greatest* good to you—giving you the highest knowledge, and filling your mind with thoughts of the wondrous power and perfection displayed in the universe, and so leading you to the contemplation of Him who made and harmonized the whole."

"I'm sure I wish I knew all about them as you do, Captain Jones," was the boy's remark.

"I know, youngster, but little concerning the stars," replied the old seaman; "only as much, I'm sorry to say, as I was *obliged* to know in order to be intrusted with the management of a ship. Ah! I wish I'd my time to come again, what a clever fellow I would be to be sure! But, unfortunately, so we all think when it's too late; so let it be a warning to you, my boy, and learn as much as you can in your young days, for when you're like me you'll be past being taught; and then to try and impress any new thing on your memory, will be like a child scribbling on the sands—the next wave will wash it all out and leave no trace behind. But come," said the old man, "we've still to get at the precise measurement of the earth, and it's getting on to dinner-time I can tell by the scent from the kitchen. Well, Owen, you know now how to tell when exactly 1 degree of latitude has been measured. But in order to do this properly, it's necessary that you should always keep to the meridian line."

"And how are we to make sure of that, sir?" asked the boy.

"That's not very difficult," proceeded the old man; "you have only to notice the time at which the pole-star is at its greatest or least elevation above the horizon—that is to say, the exact moment when it crosses the meridian of the place from which you're measuring, and then to observe as you go along

whether it continues to cross the meridian at precisely twelve *sidereal* hours afterwards (for it can do this only in the meridian line), why that will be a sure guide to you whether you are measuring in a straight course or not. So you see, lad, if you found the pole-star to attain its greatest and least altitude above the horizon in more or less than 12 sidereal hours apart, why you might be certain that you were not directly in the line of the meridian, but had gone a little way to the west or east of it. Now you understand how what's called an arc, or a certain portion of the meridian line, can be measured; and you know how to tell when you've travelled exactly 1 degree farther away from the equator, and you know also how to tell whether you've been travelling in a direct line with the meridian or not, and when you've done this you can proceed to measure how many miles there are between the two places."

"So you could, sir, easily, I should think," remarked the lad. "I suppose they measure the miles with a chain, as I've seen them do the fields?"

"Yes, youngster, it's done in some such way as that," said the sailor; "and the strange part of the business is that it's found that 1 degree of latitude is of different lengths in different parts of the world. For instance, in Peru, which is near the equator, there are somewhat less than 363,000 feet to the degree; at the Cape of Good Hope, which is about $35\frac{3}{4}$ degrees from the equator, there are just upon

364,000 feet to a degree; in England, which is about $52\frac{1}{2}$ degrees from the equator, there are nearly 365,000 feet to a degree; and in Sweden, which is about $66\frac{1}{4}$ from the equator, there are somewhat less than 366,000 feet to a degree."

"Dear, dear! how very odd!" cried Owen. "I should have fancied that as a degree you told me was the 360th part of a circle, every degree would have been of the same length."

"And so they all would, youngster," replied the old man, "had the earth been a perfect sphere; but since it's found by the most accurate measurement that the degrees are of different lengths in different parts of the world, and, moreover, that their length increases the farther you go from the equator, it is plain that the earth cannot be a true sphere, but must be flattened at the poles where the degrees are the longest; and, consequently, that it must be more the shape of an orange than that of a perfect ball. Look at our little model world," he went on, as he drew the orange globe towards the boy; "do you see how flat it is at the end where the stalk was, and also at the opposite extremity? If you were to measure it by thrusting a long darning-needle from the stalk end right through to the opposite point, you'd find that it would be a little bit shorter from the top to bottom than it is straight through from side to side. And it is found by calculation from the different lengths

of the degrees in different countries, that the diameter of the earth itself must be a little shorter from pole to pole than it is from one side of the equator to the other; that is to say, it is rather more than 7925½ miles through from one point of the equator to the other, and but little more than 7899 miles through from one pole to the other. Consequently, you see that the polar diameter, as it is called, is about 26½ miles shorter than the equatorial diameter; or, what is the same thing, the one is very nearly 1-300th part longer than the other. This is so trifling a difference, that with a 16 inch globe it would amount to only the 20th part of an inch; and, if a model of the earth were turned of this size in wood, with such a difference between its two opposite diameters, the nicest eye or hand would not be able to perceive the flatten ing. Therefore, it is sufficiently correct for 1 ordinary purposes to speak of the earth as a globe, though, when strictly described, its form is what's called an 'oblate spheroid.' There, boy, now we have done: we have measured the earth accurately —so accurately, indeed, that it is said the error, if any, cannot exceed 1 mile in the diameter; and, as convenient numbers for you to remember, you can bear in mind that in 1 degree of our latitude there are as many thousands of feet as days in the year; that a degree is about 70 miles long, and that the

earth is a little less than 25,000 miles round at the equator."*

"And now, Owen, we can pipe to dinner," said the old man, laughing.

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* The equatorial circumference of the earth is precisely 24,899 miles.

CHAPTER XII.

TRAVELLING AT THE RATE OF A THOUSAND MILES AN HOUR.

When Owen Evans made his appearance at the old sailor's cottage on the following morning, he had to run over, as usual, the heads of the several matters which the old man had communicated to him on the previous morning.

"Well, youngster," said the Captain, as soon as he had been reminded of the point where he had ended the day before, "we've measured the earth right round, and know all about the latitude. But, as I said before, we two may be situate in the same latitude and yet be many hundred miles apart. For instance, if you were at Edinburgh, in Scotland, and I was at Copenhagen, in Denmark, and your father was at Moscow, in Russia, we all of us would be in, as nearly as possible, the same latitude—a little more than 55½ degrees north of the equator—and

yet your father would be a long way from me, and I, again, should be a long way from you. So, you see, there is something more than the mere latitude required, in order to find out our exact place upon the earth. We must know not only our *latitude*, or how far we are from the *middle* or *end* of *the globe* but also our *longitude*, or whereabouts we are *across* it."

"You said, Captain Jones," remarked Owen, "that the latitude was the breadth of the earth and the longitude the length of it. But how is it that the breadth runs from one end to the other and the length goes crossways like?"

"Because, my boy," answered the sailor, "the *polar* diameter of the earth is, as I told you, not so long as its *equatorial* diameter; that is to say, the globe is 26 miles longer across from east to west at the equator, than it is from north to south, or, what is the same thing, from pole to pole. Now you must suppose the earth to be divided into 360 equal parts right round, *longitudinally* as well as *latitudinally*, and imagine that there are a number of meridian lines scored upon its surface for this purpose, and running from one end to the other of it like the marks upon a melon. Well, the latitude is always measured *along* these imaginary meridians, up or down, from the middle to either end, while the longitude is measured *across* them, *round* to the right or left of some particular

meridian. But do you cut these lines on the orange, Owen, and then you'll be sure not to forget them."

"Are those like the meridian lines on a globe, sir?" inquired the boy, holding up the orange when he had scored it up and down after the Captain's directions—thus:

"Yes, they'll do well enough," answered the old man, "though on a globe the lines are placed at every 10 degrees, and here we've put them 15 degrees apart, because, as you'll see by and by, 15 degrees of longitude is exactly equal to one hour of time. Well, now we understand, *the circles passing through each end of the globe are the meridian lines, while those across it are the parallels of latitude;* the distance *up or down* these meridians is the measure of the latitude, while the distance *across* them is the measure of the longitude—the latitude being measured *North* or *South* from the equator,

and the longitude *East* or *West* from some particular meridian."

"I don't think I shall make any mistake about that now, sir," said Owen.

"Well, you remember," proceeded the Captain, "what I told you about the poles of the heavens appearing to shift their places as you travelled north or south?"

"Oh, yes, sir," exclaimed the boy, "I recollect it very well. You said, that if we could be carried, in a moment, backwards and forwards across the equator, we should see the poles of the heavens playing see-saw in the sky—first one coming up and then the other; and that the further we went to the north or the south, the higher each of them would appear to be lifted up; while the stars, you said, would seem to slant more and more across the heavens as we travelled away from the equator, where they would rise exactly—*perpendicular*, I think you called it, to the horizon; whereas at the poles they would all move round quite—what was the word? oh, yes, quite *parallel* to it."

"Capitally said, my little fellow," cried the sailor. "Well, then you see, Owen, if you travel along any one of the meridian lines, the heavens will be continually changing their appearance to you, so that to persons situate along *the same meridian*, and consequently having different latitudes, the sky must be different at all moments; that is,

they will *not* see *exactly the same* stars, and the circles of those they *do* see will be *differently inclined* to the horizon, while the stars themselves will attain *different altitudes* above it. But to persons situate on *the same parallel of latitude*, and therefore having *different longitudes*, the vault above them will present *precisely the same* aspect; the stars will be seen to attain the *same altitudes*, and their circles to be *equally inclined* to the horizon. So at different longitudes, remember, there is *not*, as there *is* at different latitudes, any marked change in the appearance of the heavens to tell us that we are at different parts of the earth."

"Then how can you find out your difference of longitude, sir," asked the pupil, "if there's nothing in the heavens to show that you're in a different place?"

"Not quite so quick, youngster," cried the old Captain; "for though persons situate *in the same latitude, but at different longitudes*, see the same stars, and these attain the same altitudes, they *do not cross the meridian*, or, what is the same thing, reach their greatest and least heights, *at the same time;* while to persons having *the same longitude, but in different* latitudes, though the stars do *not* attain the same altitudes, they *all come to the meridian at the same moment.* So, bear in mind, Owen, that at *different latitudes* the stars attain *different altitudes*, but cross the meridian at the *same time*,

whereas at *different longitudes* the stars attain the *same altitude* but cross the meridian at *different times.*"

"I can partly understand that," observed the lad; "for as the stars seem to go over our heads from the east to the west, of course they can't pass over my head at the same moment as they do over the head of any one else who is farther to the east or west than I am."

"There's a sharp little man," replied the tutor; "and you're quite right too. Well, then, you perceive, lad, that as we learnt to tell the *latitude* by the *different altitudes* attained by the sun and stars at different distances north or south of the equator, we must now try if we can't learn to tell the *longitude* by the *different times* that the sun and stars come to the meridian at different distances east or west of some well-known place. But, to begin; let us understand what would happen if we could be in different places to the east or west *at the same time.* Let us suppose, my little man, that you are possessed of the wonderful flying carpet spoken of in fairy tales, and that you can transport yourself by its means round the world at a moment's notice. Well, we will imagine you to be at the Cape of Good Hope, where you 've just measured the sun's altitude with your quadrant, and found it to be exactly on the meridian above you, marking the very moment of noon, and the people there are abroad

with their large umbrellas to screen themselves from the fire of its rays. Then away you fly to Cape Horn, the extreme point of South America, and, reaching it the instant after, *there* you perceive to your astonishment the east still crimson with the dawn, and the sun like a huge liquid ball of fire just peeping above the horizon, while the workmen, newly risen from their beds, go trudging along, yawning, on their way to their labour. Away you fly again, and the next moment you are at New Zealand, where you find the stars sparkling in the sky, the moon silvering the sea with her beams, the villages all still, and the country dusked with the shadows of night. In an instant you are off once more, and gain Australia; here you behold the western quarter of the sky purple with the last rays of the setting sun, and the evening star shining alone in the vault, while the lights are beginning to twinkle, one after another, in the casements, and the cattle in the plains lowing as they go to their places of shelter for the coming night. Flying from this by means of your magic carpet, you return to the place you started from, and arriving there, the moment after you quitted it, you see the sun still high in the heavens, with his beams raining light and heat upon the land and sea, and bathing the earth in a flood of golden lustre."

"How beautiful it would be to see all this,"

exclaimed the delighted boy; "but of course there are no such things as magic carpets, Captain Jones?"

"No, youngster," returned the old man; "but there are things much more wonderful, and quite as rapid, now-a-days; they are what are called electric telegraphs, for by them it's quite possible to communicate with different parts of the earth as swiftly as the lightning travels. So if there was only a wire reaching to the countries I have just spoken of, and you were to send a message along it, inquiring whereabouts the sun was in those parts when it was over your head at the Cape of Good Hope, you'd have just such an account as I have given you of the different time of day at each of those places. Strange, too, as it may appear to you, although there 's no telegraph wire right round the earth yet, a message often reaches a place some time before it left the station it was sent from; for as the lightning travels a good bit quicker than the sun appears to do, a message leaving a part of the earth, say at exactly 12 o'clock, would arrive at another part that was 1 degree to the west of it, nearly 4 minutes *before* the time of its leaving the first."

"How funny!" cried Owen.

"Yes, it may sound funny," replied the sailor, "but it 's quite true for all that. However, instead of supposing you to make the tour of the earth in an instant, and so to see every hour of the day all at once, let us imagine you to travel round it at the

rate of rather more than a thousand miles an hour. Then as the earth is 24,900 miles round, you 'd complete your tour of it in exactly 24 hours, which is just the same time you know as the sun appears to do the journey in. Let us imagine, moreover, that you go from *east to west*, as he seems to us to do—then what do you think would occur? Why, instead of there being any sun-rise or sun-set to you that day, or any morning, or evening, or night, you would have one continuous noon throughout the 24 hours; you would have no 1 o'clock, nor 2 o'clock, nor 3 o'clock, and so on, but one entire day of 12 o'clock; for as the sun was on the meridian at the time you started, and we suppose you to go right round the earth in precisely the same time as he does, it is plain that *you and he would cross each fresh meridian exactly at the same moment*, and consequently, although one hour would have elapsed when you both had travelled 15 degrees, there would be nothing in the appearence of the heavens or the earth to note any difference in the period of the day. So that really, during those 24 hours, time would have seemed to you to have stood still, and when you returned you would have missed a morning and an evening, and consequently have lost one entire natural day as much as if it had never existed."

"Oh! isn't it curious, sir?" inquired the lad; "but I can see how it's done."

"Yes, lad!" continued the Captain. "But come, I think we understand now, Owen, that the world is a great clock, marking a different hour at every 15 degrees of longitude, so that when it marks 12 o'clock with you, it is 1 o'clock at 15 degrees to the east of you, and 11 o'clock at 15 degrees to the west, and so on all round the world—the time of every place being just an hour earlier or later, according as it is that number of degrees eastward or westward of another meridian. Well, then, lad, since 1 hour of time is exactly equal to 15 degrees of longitude,* it is plain that we can use this difference of time between places having different longitudes, to measure their distance to the east or west of one another; for we have only to provide ourselves with an accurate time-keeper, and having marked the moment by it when a certain star appears to cross the meridian of one place, then to notice how much earlier or later the star seems to pass over that of another, in order to find out

* A degree of longitude is divided into minutes and seconds, like hours; and therefore, as 15 degrees of longitude are equal to 1 hour of time, 15 minutes, or 15 seconds of longitude must be equal to 1 minute or 1 second of time. One degree of longitude is equal to 4 minutes of time. One degree of longitude is, at the Equator, rather more than 69 miles long; 1 minute of longitude about 1 mile 800 feet; and 1 second of longitude 101 feet; while 1 hour of time corresponds to 1035 miles of space at the equator; 1 minute of time to 17¼ miles there; and 1 second of time to about 1500 feet.

how many degrees of longitude the two places are apart.

"And is that the way you used to do it at sea, sir?" asked Owen.

"No, my boy, it was not quite so simple as that," answered the Captain. "You see, chronometers are still too imperfect for us to trust entirely to, and we therefore require some mode of determining our longitude which is less liable to error, and upon which the Captain of a vessel can securely stake the lives of himself and crew, as well as the fortunes of his employers. However well a chronometer may go for a few hours, or even days, still during long voyages, lasting for months and sometimes years, a very slight irregularity becomes so magnified as to make us seek for some more trusty guide than a mere bit of clock-work to direct us across the seas. It's true ships generally carry more than one chronometer with them, so that each may check the other. Still, sailors never rely on them alone. On land it has been proposed to use a series of signals as a means of communicating the time from one place to another—such as letting off rockets at stated intervals; but as these can be seen only at a distance of 50 or 60 miles, you can readily understand the large number of stations that would be required in order to propagate the true time at the place which the longitudes are reckoned from, over a small extent of country. Instead of these artificial signals,

however, others have proposed that geographers, and such as are interested in determining the longitude of different places, should avail themselves of natural ones, which are visible at once over a whole hemisphere. Such natural signals are afforded us by the eclipses of the moons to the planet Jupiter; and, as the time at which these eclipses will be seen to occur at Greenwich can be *foretold* by calculation from previous observations, it is evident that they may be used as a means of making known the true time at Greenwich at the moment they are seen to take place in any other part of the world. Accordingly, a person observing any one of these eclipses from a distant place, and noting the moment of time at which it was found to occur, might make use of the *predicted* Greenwich time — in the same manner as if he had received a special communication, then and there, from the spot, telling him the very hour, minute, and second that the hands of the Greenwich clock were marking at that particular instant. Then finding the difference between that and his own time, he might at once proceed to determine how many degrees longitude he was to the east or west of the Greenwich meridian."

"This seems quite as clever as the way of finding the latitude by the height of the Pole-star, or the sun at the time of its crossing the meridian, sir," remarked Owen. "I never should have thought it

was possible to have a communication, as you call it, from Greenwich while you were in the middle of the sea."

"But you see, youngster, it *is* quite possible," replied the Captain; "and if we hadn't some means of telling what hour it is by the Greenwich clock, when we are hundreds of miles away from it, no ship could traverse the sea in safety. However, it 's not by the eclipses of Jupiter's moons that sailors ascertain their longitudes, for those eclipses happen only at certain times, and even then you can't get the longitude very precisely by that method. What 's more, too, the observation cannot be well made at sea. So we must find out some other means which are of more regular occurrence, and which the sailor can avail himself of almost every night."

"I wonder what they are," said the boy half to himself.

"Well, lad," proceeded the old man, "if there was a clock in the heavens with a dial plate and hands to it always marking Greenwich time, the longitude could easily be come at."

"Yes, of course it could," exclaimed Owen; "but there isn't any such clock, sir."

"Don't make quite so sure of that," interposed his tutor. "Let us see what a clock really consists of. The dial-plate, you know, has a set of marks upon it at equal distances, and the hands, by passing along these, point out to us what the time is, or how many

minutes have passed since we last looked at the dial-plate and found the hands in a certain position. If, however, the marks were placed not at equal, but at unequal distances round the dial-plate—and if the hands, instead of being in the centre, were put a little bit on one side—and if again, instead of continuing to move round always at the same rate, the hands went sometimes slower and sometimes quicker than at others—still we should be able to tell what time it was by such a clock quite as truly (though perhaps with a little more trouble) provided in the first place that we knew the precise distance between the hour and minute marks; and secondly, that we knew exactly how much the hands were placed out of the centre; and thirdly, that we were perfectly conversant with the nature of the works, so as to be able to tell with certainty at every moment at what rate the hands were travelling, or, what is the same thing, how far they would travel round the dial in a certain time."

"Yes; but such a clock as that, sir, would be a funny kind of time-piece, indeed," laughed the little clockmaker. "With the hands going all askew and running along sometimes, and creeping round at others; and the hours too put round the dial-plate all unevenly—why who 'd ever look at such a queer thing?" and the boy, full of his knowledge of the construction of dial-plates, and hands, and clock-work, chuckled immoderately at the idea of a time-

piece so thoroughly different from all he had seen and made.

"Such a clock," smiled the Captain, "might be looked upon as a very poor one, no doubt. If, however, Owen, it was the *only one* we had to tell the hour by, and if an immense amount of money and thousands of lives depended on our having a perfect knowledge of Greenwich time, we should think it a most valuable boon, and consider no labour thrown away that served to make us acquainted with the principle of its movements, or that taught us how to read the Greenwich time by it correctly. Well, the sky is the illuminated face of the clock I've been speaking of; the stars are the hour and minute marks, set like jewels round the dial-plate; and the moon is the silver hand which, though apparently moving always at the same rate, is found when accurately watched to be travelling quicker sometimes than at others—completing the circuit of the starry dial in the period of a month; and gliding over some of the stars in her course, so as to screen them from our sight, and skimming beside and between others. Now, the moon's place among the stars can at any period, when the weather admits of the observation, be accurately measured by an instrument called a sextant,* much

* A sextant is an instrument like a quadrant, with a small telescope placed where the eye-piece is in the latter instru-

in the same way as we should measure by a pair of compasses how far the hour hand of a dial is from any of the figures placed around it; and so we can find out at any time, by the known rate of its travelling, the precise moment of the day or night. Such, boy, is what is called the lunar method of determining the longitude; for it is by studying the moon's motion among the constellations that astronomers are able to foretell with the greatest certainty—years even before the time—the precise place that the moon will be seen to occupy among the stars, from every part of the earth at every moment, of every day, in every year. This being done in true Greenwich time, and the distance of the moon from the most conspicuous of the heavenly orbs calculated and published, long beforehand, in Government books for the guide of those traversing the seas, it is evident that directly the Captain of a vessel measures with his sextant the moon's distance from any of the 'longitude-stars' (as they are called, from the fact of their position in the sky having been determined for that purpose with the greatest care)—directly, I say, he has done this, and noted how many hours, minutes and seconds it is after mid-day with him when he makes the observation, he has indeed compared the time of

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ment. The "limb," or graduated arc on which the distances are measured, consists of the sixth of a circle instead of the fourth, and hence its name.

the part of the world which he may be in, with that of Greenwich, and so determined his longitude east or west of that place—from which all English longitudes are reckoned. And now you know, youngster, how the latitude and longitude of places are made out; or, what is the same thing, you know how it 's possible to tell the exact spot you are in, and whither you are going, and how far you have travelled, where there are neither milestones nor sign-posts, nor indeed any mark on the earth to distinguish one part of it from another."

"Oh! thank you, sir," cried the little fellow. "I 'm sure I shall never see the moon again floating in the heavens, but I shall think of the hundreds of ships far away at sea, and how anxiously the sailors are watching its path through the sky, and measuring its distance from the different stars round about it. But, Captain Jones," added the boy, after a moment's pause, "you always speak of the sun and stars *appearing* to go round the earth. I've heard father, too, say that the earth itself turns round, but I never could make it out. I'm sure, if there is any believing one's eyes, I see the sun rise over towards Bronllys and set towards Builth every day, so that it *must* go right across the sky."

"Let us ascertain, then, in the first place," answered the sailor, "whether seeing is always believing, and whether our eyes may not deceive us sometimes, leading us to fancy things in motion

which we know to be positively at rest. Now, you take this penny, Owen; go to the end of the room and hold it facing the window about a foot away from you, so that it may be in a line with the bridge of your nose; then shut the right eye, and you will see the penny with the left eye, in a line with the right side of the window. After that, shut the left eye and open the right at the same moment, and you will see the coin appear to shift over from the right to the left side of the window frame, so as to seem to travel the entire width of the casement."

Owen made the experiment as directed, and cried out as he did so, "Oh! yes, so it does, I declare. How very funny! It seems to me to jump right over from one side to the other; and as I keep opening first one eye and then the other, the penny appears to move backwards and forwards just like what Mr. Wilkins calls 'the bob' to the pendulum."

"And yet I suppose," said the old man, "you are thoroughly satisfied that the penny remained in the same place all the while?"

"Oh! yes, I'm sure of that," exclaimed the boy; "for I held it tight."

"Well, then, Owen," added the sailor, "you must come to the conclusion that your eyes are not to be trusted in this respect, and that things may appear to you to move when you are certain they are standing still. But now let us see how we know that

we are changing our place at any time. Of course if we walk or run we are conscious that we are moving by some effort of our own—though even then we might be deceived. For if you were aboard a ship that was sailing at the rate of three knots an hour through the water, and you started to walk from the head to the stern at precisely the same rate as the vessel was travelling, you'd remain exactly in the same place, and instead of going to the stern, the stern would come to you, since you 'd only prevent yourself being carried along with the ship as it went. So, though you would have appeared to have altered your place with regard to the different parts of the vessel, you would really have remained where you were, with regard to the different objects outside of it. However, don't let us trouble ourselves with this kind of motion, but consider only what occurs when we are carried along by some power other than our own. How are we to tell we are moving *then*, supposing we close our eyes, and so shut out all external objects from us?"

"I should know very well I was going along by the jerks and jolts I should feel on the road," answered the boy, sharply.

"Ah, but suppose the road was perfectly even," added the Captain, "and the conveyance we were travelling in was perfectly silent. How would you tell *then*?"

"Why, I should know by the air blowing against my face as I went through it," replied Owen.

"Yes," went on the old man; "but if the air travelled with you as it does when you pull the windows up in a carriage, would you have any sense of it *then*, think you?"

"Well, no, sir," said the lad, after a few moments' reflection; "I don't think I *could* tell in such a case as that—at least, if I wasn't allowed to look at the things outside."

"No, my boy, you could *not* tell," returned the sailor. "You would know certainly when the conveyance moved on, or when it stopped, or if it turned a sharp corner; for all these would be alterations in the uniformity of your motion, which your senses could give you positive evidence of, since you would be jerked back in the one case, forward in the other, and on one side in the third. But if the movement was perfectly steady, and maintained always in the same direction, and at the same speed, there would be nothing but external objects to guide you. Now this is exactly what occurs in the cabin of a large vessel going smoothly through the sea. Not a thing tells us there of the way we are making, unless, indeed, we listen to the sound of the water rippling past the sides of the ship. There we read, we sit, we walk, as on land. If a ball be thrown straight up, it falls back in the hand; if dropped, it lights at the feet. Insects buzz

around us, the same as if we were sitting still in the open air; and the smoke ascends from our cigar in the same manner as it would on shore. If, however, we go on deck, the case is altered. The air, not travelling with us, drifts back the smoke from the galley fire and the streamers from the mast-head, as well as any light object, such as feathers, that may be cast over the ship's sides, though really these remain at rest, and we leave them behind. In the case of the movement of the earth, however, we must remember that it is a motion *pervading the whole*—a motion common not only to the solid mass beneath, but also to the ocean which flows around it, as well as the air that rests upon it, and the clouds that float above it. Then, as such a motion,—in which all things connected with the earth partake alike,—would displace no object, and interfere with no natural processes, nor produce any shocks or jerks, or tossings from one side to the other, it is plain that we might be utterly unconscious of it. Since all things on the surface would maintain the same places one among another, we could have no more sense of it than if we were travelling in a balloon, where the motion, even in the most furious hurricane, is so imperceptible, that it is impossible to tell whether we are rising or sinking, or which way we are drifting, excepting by pieces of paper thrown over from the car. Well, then, as it is only by *external* objects that we can

gain a knowledge of our change of place when the motion is *equable and steady*, let us turn our eyes to the heavens, and see what they will tell us upon this matter."

"Of course, sir, if the earth moves *altogether*, and goes on always steadily," said Owen, "I don't see how we *are* to know whether it's moving or not. But how could the motion of the earth make the sun and stars appear to go over it, as they do?"

"If you'd ever been on board o' ship, lad," replied the seaman, "and looked over the side of the vessel, you'd have seen the water hurrying past it in an opposite direction—this alone appearing to move, while the vessel itself seemed positively motionless. It is the same with the log when cast upon the sea; though you know it to remain where it is thrown, still, you cannot but believe it to be carried by currents rapidly away from the ship. But it is when the cry of 'A man overboard' is raised, and you catch sight of the poor fellow in the water before the sails are put aback, that the illusion is most complete; for, though you see him struggling towards the vessel, he appears to be drifting fast astern, as if hurried from the hull by some adverse torrent. It's at such times as these, Owen, that the illusion becomes more strongly impressed on the mind, because, being anxious for the poor fellow to near the vessel, we are more particularly alive to the appearance of his being carried from it."

"I dare say, sir," said the youth, in a piteous voice.

"Again, boy," went on the tutor, "when sailing near the shore, the whole line of coast, with its cliffs, trees, meadows, and buildings, appear to be gliding past us, while we seem to be standing still; for since the different parts of the vessel always keep the same position with regard to ourselves, we fancy them to be at rest, and the motionof the ship to be transferred to the objects *outside* of it, and that in the opposite direction to its own. In a railway carriage, too, the same illusion may be noticed; for if, while the train is darting along, we fix our eye upon some object midway between it and the distance, the whole landscape will seem to be thrown into rotation, and the trees, and hedges, and houses, to move round that object as a centre,—the fields in the foreground appearing to rush rapidly backwards, or the contrary way to the one we are travelling, and the hills in the distance to be carried gently forwards in the same direction as ourselves."

"But is there any reason for all these strange things, sir?" inquired the boy.

"We are coming to that, youngster," replied the Captain. "You see, motion is not a *perception* of our senses, but an *inference* drawn by a rapid process of reasoning whenever external objects appear to change their places with regard to ourselves. Then, as this apparent change of place is the same, whether we or the objects themselves move, it

becomes difficult to tell whether they or ourselves are really in motion. Accordingly, when we form part of a *large moving mass*, such as a ship or the earth, and the things *immediately round about us* maintain the same position with respect to ourselves, we are deprived of our ordinary means of judging, and so cannot help fancying that we are at rest—ascribing the seeming alteration of position among *distant* objects to some motion of their own."

"I think I can make out what you mean, sir," said Owen. "When we are moving along by ourselves, the objects nearest to us seem to go the quickest past us. But if we are carried forwards with a number of other things, so that what is nearest to us appears to stand still, then we fancy *we* are standing still too, and that the things in the distance are going on instead of us."

"Exactly so, my boy," replied the sailor; "for it's by these *near* objects we always judge whether we are moving or not. Suppose you are in a large wood, where, look which way you will, you can see nothing but trunks of trees, one after another as far as your eye can carry you. Well, if you were to move but a few paces then, you'd find a great change in the apparent places of all the nearer trunks, both with respect to yourself and among one another. Some of the trunks which previously hid those behind them from your view would seem

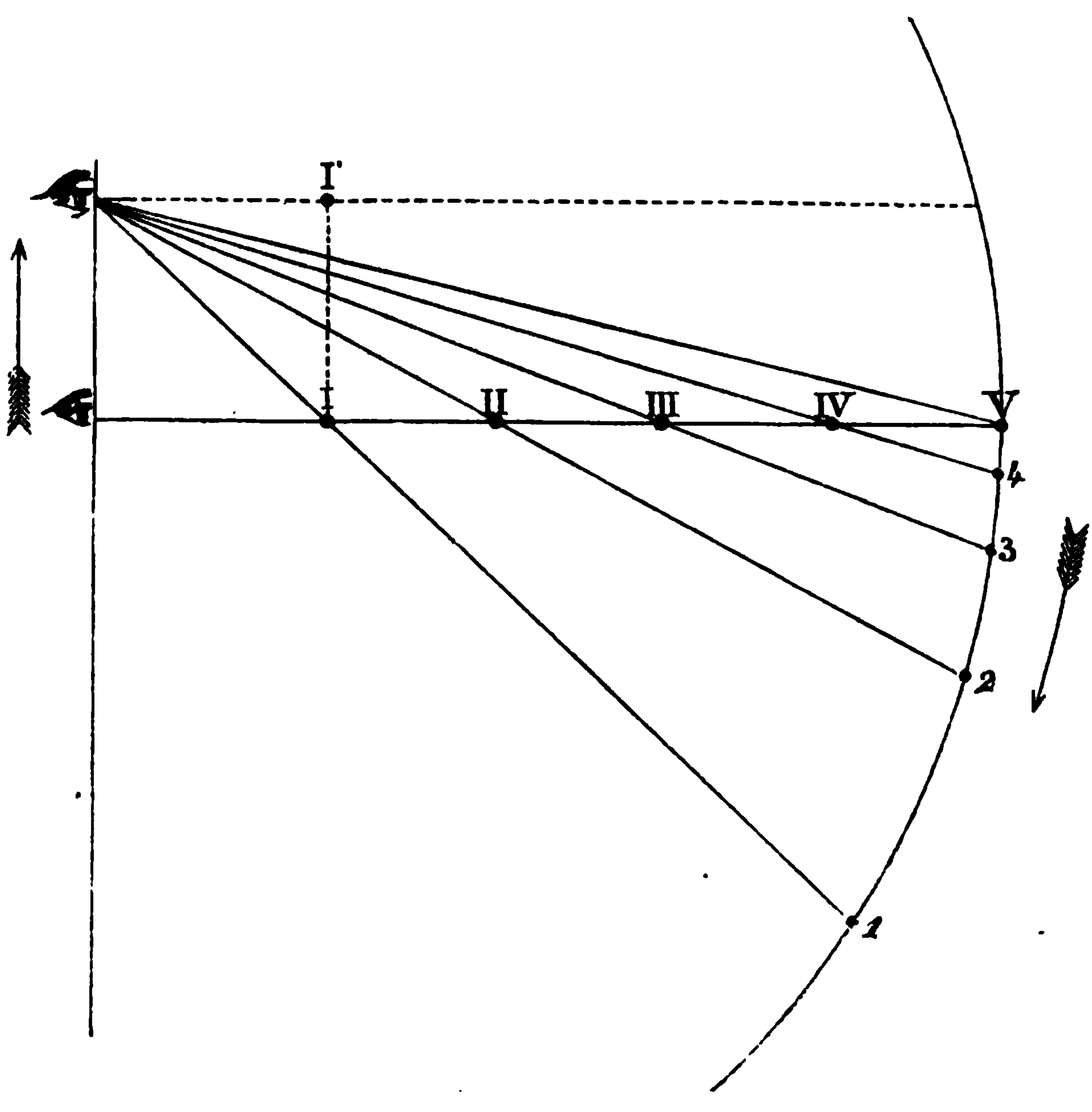
to pass from before the others, and allow the hinder ones to come into sight; others, that you could before see the light between, would appear to glide one over the other, and to shut out the more distant ones; while among the trunks in the extreme distance, you would observe no great change of position."

"Oh, I remember, when I've been to the spruce plantation down at Llangoed with father," exclaimed the lad, "I've seen the trees, as I walked along, move all round about me. I've watched them often and often, and wondered whatever *could* make them do so."

"Well, youngster, if you'll wait a few minutes, I'll tell you," added the old man. "Now, if you had walked along through the wood in a straight line, and noticed well what occurred, you would have found that the trunks on the right and left hand of you would have seemed to have moved *backwards* as you went *forwards;* those that were the nearest to you on your right or left would have appeared to have receded the farthest, and the more distant ones to have gone back only a short way; while those *right before* you would have remained in the same line as they were at first, but seemed to have grown bigger and bigger as you approached them; and those *right behind* you to have kept in the same line as before, but to have become smaller and smaller as you went from them. Well, Owen, the reason of this is, that every object which is on a level

with our eye is referred by us to some point of our horizon—which, you know, is a circle having always ourselves, or rather our eye, for its centre; and as, when we move along, our horizon shifts—for we carry with us, remember, the circle limiting our view,—the points on the horizon, to which we refer near objects, appear to revolve about the objects themselves as centres—the swiftness with which they seem to do this being according to their nearness to us."

Then the old man directed Owen how to describe the following diagram.



"Now, to make the matter clearer to you," went on the Captain, as soon as the diagram was finished, "we'll suppose the five dots here in a straight line to be the trunks of five trees in a wood, and the last of them to be in the extreme distance. Well, if, before proceeding in the direction shown by the arrow on the left, you were to look along those trees, the first would appear to cover all the others, and exclude them from your sight. But as you journeyed through the wood, the trees would begin to separate, each becoming visible to you, one after another; so that if, when you had gone a few paces, you looked back towards them in the manner represented by the eye at the top of the drawing, they would no longer appear hidden by the front one, but seem to have spread wide apart, and to have travelled backwards along the circle of the horizon as you went forwards, the nearest tree appearing to have moved the greatest distance, and the most remote to have, comparatively, stood still. That is to say, the dot or tree marked I, would have seemed, as you journeyed from one point of sight to the other, to have passed along the arc of the horizon from V to 1; for instead of appearing in a line with the most remote tree at V, it would then appear in a line with the point marked 1; while the tree marked II would seem to have moved from the point V to 2, and so on, each more distant tree appearing to have moved through

a smaller arc of the circle, till the tree marked V, or that in the extreme distance, would seem to have remained, as nearly as possible, in the same spot. This is what is called parallax.* If, however, we imagine the first tree to stand for the mast of some ship we are sailing in, then, as this will travel with us, going forwards as we go, and always maintaining the same position with regard to ourselves—as indicated by the dotted lines in the drawing—we shall

* *Parallax* is simply the *apparent* change of place in an object, which arises from a *real* change of place in a spectator—that is to say, it is the different direction an object is seen in from a different point of sight. The apparent motion of a near object on viewing it with first one eye and then the other, as with the penny before described, is due solely to this cause; for looking at the same object with the other eye, is merely regarding it from another point of sight, and the effect is the same whether the difference between the points of sight amount only to 2½ inches (as with the two eyes, when the observer is stationary and uses each of them successively) or to some hundred feet, as represented by the two eyes in the diagram—where the observer is supposed to have moved on some considerable distance. The same principle, carried out to the stars as seen from different parts of the earth, is one of the most important laws in Astronomy. Let us suppose the dot IV in the engraving to represent, instead of a tree, some planet as seen from the earth's centre by the lower eye, and the point 4 the direction in which this same planet would be seen by an observer on the earth's surface as represented by the upper eye, then the *difference between the apparent positions* of this body, when viewed from the surface of the earth and its centre, would be what is called the planet's "*parallax*," and be equal to the arc or portion of the circle contained between V and 4; that is to say, this is the distance the planet would appear to have been displaced.

be deprived of the principal means of judging of our motion; accordingly, perceiving that the object nearest to us stands still, instead of travelling past us at the greatest rate of all, we shall believe that we ourselves have not moved, and that the apparent change of place among the more distant objects proceeds from some motion of their own. In the same manner, too, as we are led to believe things to be *moving* that are really *at rest* by transferring our own motion to them in the contrary direction, so we may be induced to fancy we ourselves are *going on* in a certain line when we are positively *standing still*, by transferring to ourselves the motion of some object travelling in the opposite line. Thus we can be made to imagine that we are being carried forward by the mere sight of something moving backward to us. This is frequently the case with passengers in a railway carriage on seeing another train come in at the moment they are expecting to start. No sooner are the other carriages seen to move past their own in the opposite direction to the one they are about to travel in, than, (the effects being the same whether they are carried past the others or the others past them,) all feel themselves to be moving, and a cry is raised of 'Now we're off.' Well, Owen, I think we understand, after all this, that we have no positive sense of motion in ourselves when we are carried along steadily in one direction, and that, under such circumstances, it is

merely by the apparent change of place among external objects with respect to us, we *come to the conclusion* that we are in motion. We understand, too, that when the things immediately round about us are carried along with us, we are deprived of our ordinary means of judging, and not only believe ourselves to be at rest, but fancy our own motion to be transferred to remote objects and that in the opposite direction."

"Yes, sir, I understand all that perfectly," said the boy.

"Now, Owen, let us suppose," proceeded the Captain, "the earth to turn round, and see what would happen. In the first place it is clear that we, and every one else, would be unable to perceive any motion in it, for our horizon—the circle limiting our view—being carried round with us, would, so long as we remained in the same place, constantly comprise the same objects, and be itself bounded by precisely the same distant hills and plains. We should have the same landscape continually before our eyes; there would be the same river running through it always in the same direction, the same woods pluming the same fields, the same mountains piercing the sky from the same spot, the same homesteads studding the same plains, and the windmill on the hill always at the same point,—that is to say, the various objects round about us, which serve us for landmarks, would always retain with

respect to us and themselves the same invariable situations—the east and west, like the north and south, ever lying over against the same parts of the distance. Then the perfect evenness and regularity of the motion of so large a mass—a motion which it would be impossible to feel, and which, from all things immediately around us partaking in it alike, it would be impossible also to infer from any change among the objects on the earth—all would naturally prevent us having any suspicion that we and everything about us, which appeared so still, were continually shifting our places with regard to the centre of the earth itself. When, too, we directed our attention to objects not participating in our motion, such as the sun and stars, we should unwittingly transfer our own movement to them in a contrary direction, and so *they* would seem to be constantly moving round *us* rather than *we* round *them*."

"Yes, I can see now, sir" remarked the lad, "that the appearance would be all the same whether the earth went round the sun or the sun round the earth. But, Captain Jones, if it *would* be all the same, why should they want to make out that the earth goes round the sun?"

"Why, my boy, there are several reasons," replied the old man; "for that being more likely than the sun and stars moving round the earth. For if the latter were the case the sky must be solid

so as to admit of the stars being fixed to its surface; for as they always keep the same places among themselves, and form precisely the same figures, night after night, it is evident we must, if we suppose them to go round the earth, believe them to be fastened in some way or other to the heavens, in order to prevent any derangement occurring among them. Again, the enormous rate that the sun and stars must travel at in order to complete their revolutions about the earth in the course of 24 hours, is beyond all belief. The sun, for instance, we know to be 95 millions of miles removed from us, therefore if it revolved about the earth day after day, the diameter of the orbit it would describe being no less than 190 millions of miles, the length of the entire distance it would have to travel from noon to noon again would be more than thrice that extent, or as much as 595 millions of miles; consequently, to complete such a circuit in the course of 24 hours, it must move, at the very least, at the rate of 24 millions of miles every hour. Whereas, in the case of some of the fixed stars, whose distances have been found to be upwards of 650 thousand times our own distance from the sun,* they would have to move at the enormous rate of about 4000 millions of miles per

* The above is the measurement of Bessel, from the parallax of the star in the beak of "the Swan," which is the constellation at the fork of the Milky Way.

second in order to travel round the earth once every 24 hours. If, however, we suppose the earth to turn round on its axis once in the same time, the parts at the equator, where the motion would be the most rapid, need move only at the rate of 1035 miles an hour, or 17¼ miles a minute; and this not only agrees with the facts observed respecting the difference of gravity at the equator and the poles,* and fully accounts for all the appearances of the

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* The difference of gravity at the equator and the poles has been shown, by accurate observations with the pendulum, to amount to one 194th part of the entire weight of all bodies; that is to say, 194 lbs at the equator would weigh 195 lbs at the poles. Supposing the earth, however, to move round, the difference in the weight of bodies arising from the different rates of motion at the equator and the poles, should amount to only one 289th part of the whole, that is to say 289 lbs at the equator should weigh 290 lbs at the poles. The observed loss of weight therefore is one 590th part more than what should arise from the different rates of motion. But the polar diameter of the earth is one 300th part shorter than the equatorial diameter; consequently objects at the poles would be so much nearer the centre to which all gravity tends. Now it is found by calculation that owing to the flattened form of the earth, the attraction at the poles would be exactly one 590th part more than at the equator; and this, with the increase of one 289th part arising from the slower rate of motion there, makes up exactly the total increase of one pound weight in every 194 lbs, which has been proved by observation to occur in all bodies going from the equator to the poles. Therefore, as the loss of weight at the equator is made up of two items, and one of these items exactly corresponds with the loss that would ensue (owing to the parts travelling at a greater rate there) were the earth in motion, we are thus furnished with a convincing proof that it *does* move.

heavens, but is the only supposition upon which we can explain the movements of the sun and moon as well as those of the planets among the constellations."

"But what are the movements you speak of, sir?" asked the boy; "and how do they prove that the earth really moves, and not the stars?"

"Well, youngster," replied the Captain, "if *all* the heavenly bodies invariably preserved the same place among one another; that is to say, if, like the landmarks on the earth, they always kept exactly the same distances and bearings, perhaps then we might come to the conclusion that the earth was at rest in the centre of the universe, with a hollow crystalline sphere rotating about it, and carrying the sun, moon and stars, somehow or other, along with it round the globe day after day. But if *all* the heavenly bodies do *not* continually preserve the same places among one another; and if some of them appear to move in a *contrary* direction to the general course, so that while the rest are being borne *forward* day after day, from *east to west*, these appear to be constantly changing their places with respect to the others, and to travel among them in a *backward* or *westward* direction, we must at once abandon the supposition of a solid sky carrying the heavenly bodies round with it, and admit that some of the orbs above us have movements peculiar to themselves."

"Are there, then, any heavenly bodies, as you say, moving the *contrary* way to the others, Captain Jones?" inquired Owen.

"Yes, boy," added the old man. "Some of the most conspicuous of them are continually changing their places amongst the rest. The *fixed stars*, as they are called, are so named simply because they always appear to maintain the *same* position with respect to each other, and to form now-a-days precisely the same figures with those near them as history tells us they did centuries ago. But, besides those, there is a class of heavenly bodies termed '*planets*,' or *wandering* stars, which for the most part appear to the naked eye only as the largest and most brilliant stars; now these, if their places among the other stars be noted and pricked on a chart of the heavens from time to time, will be found to make, like the sun and moon, a complete tour of the constellations in different periods; and to do this too in the *contrary* direction to the apparent daily movement of the entire firmament, so that while being carried *forward* like the rest from *east to west*, they appear to move also *backwards*, from *west to east*, among the others, returning after a longer or shorter interval to the same part of the heavens as they previously set out from. Now, it is from their continual change of place in the heavens, that these bodies have been denominated, in contradistinction to the *fixed* stars, the *erratic* stars, or wanderers; for that is the literal

meaning of the Greek word which they derive their name of '*planet*' from."*

"Oh! then there are wandering stars as well as fixed stars in the heavens," interposed the lad. "But how am I to tell a planet from a fixed star, when I see one, Captain Jones?"

"Why, my boy," returned the Captain, "a planet doesn't appear to twinkle as the fixed stars do. We can't talk though about the planets now. But as I was saying, these planets have a movement proper or peculiar to themselves, and not only they but the sun and moon also. With the moon, indeed, the change of place is so rapid and remarkable, that her alteration of position, with respect to such bright stars as happen to be near her, may be noticed any fine night in a few hours; and if her position among the constellations be observed on two nights following, her different situation among them cannot fail to be immediately evident to us. Again, the sun's apparent *backward* motion in the heavens is constant and rapid, though, owing to the stars being invisible to the naked eye in the daytime, this is not so readily perceived, but requires a telescope to be used, and the observations to be continued for a longer time, in order that it may be detected. If, however, we bear in mind that the sun's altitude at noon-day in summer is greater

* πλανητης, a wanderer.

than at noon-day in winter, and that the stars which are visible to us at night vary with the season of the year, we shall be convinced that a great change must be continually going on with respect to the sun's place among the constellations."

"But sir," again interposed the boy, "I can't make out how you can tell that the sun and moon and planets go backwards as well as forwards every day. I can't make out how the earth turning round can make them appear to go two different ways at once. I understand quite well that if we fancy the earth to move from west to east, it will account for the stars seeming to go the contrary way. But, if that's the case, how can the motion of the earth make the sun appear to move in two different directions at the same time?"

"Why, lad," responded the sailor, "you must bear in mind that the earth not only turns round on its axis like your peg-top when it's spinning, but it moves round the sun as well, just in the same manner as your top sometimes does when it describes a circle as it skims over the ground. Now the two motions of the earth—its daily motion round its axis, and its yearly motion round the sun—are both performed in the same direction—viz., from *west to east*, or *contrary to the way the hands of a clock move;* so that when the earth is at any one part of the ecliptic, the sun will appear to be

in the opposite part of it, and while the earth is travelling in one direction through the *one*-half of the circle, the sun will appear to be journeying the contrary way through the *other* half, just in the same manner as the trees in the wood appeared to go backwards as you went forwards. But since the earth in passing along opposite halves of the circle must itself travel in opposite directions, going along one half from left to right, and along the other from right to left, the sun will consequently appear to travel round the ecliptic in the same direction as the earth itself."

"But it's very strange, isn't it, sir," remarked the lad, "that the sun should appear to travel the same way as the earth round the heavens every year, while he seems every day to be going the opposite way?"

"Now, you run into the back room and bring me that big atlas," said the old man; "and there I'll show you the line of stars that the sun appears to travel through every year. You'll understand the matter much better then."

The little fellow soon reappeared carrying the huge volume on top of his head—for it was too large to put under his arm—and having placed it on the table, the old man wheeled his chair up to it and turned to the plate he had mentioned, of which a representation is here annexed.

"Oh! how beautiful!" cried Owen, directly the book was opened. "Why there are all kinds of

beasts and fishes and men; and there's a pair of scales, I declare."

"Yes, my boy," smiled the Captain," they are the figures the old shepherd-astronomers fancied the different groups of stars to resemble. This line with the degrees marked along it, and going right through the figures, is the 'ecliptic,' or the path that the sun appears to take every year through the constellations. Only one half of this belt of stars is visible at the same time, and in 12 hours afterwards the other half comes into view. The brightest of the constellations lie between 'the Bull' and 'the Scorpion.' In the neck of 'the Bull' may be seen 'the Pleiades,' or 'Seven Sisters,' while in his head is a star of the 'first magnitude,' called 'Aldebaran.'* In the head, too, of one of 'the Twins,' is another of the brightest stars, termed 'Castor.' A third very brilliant star, named 'Regulus, appears in the forepart of the body of 'the Lion;' and a fourth, styled 'Spica,' is visible in 'the Virgin'—at the ear of corn she holds; while a fifth denominated 'Antares,' may be observed in the body of 'the Scorpion.' Now, you must imagine the ecliptic, or circle drawn through the stars here, to be 596 million miles round, and 190 million miles across,

* In the head of the Bull the *Hyades*—a cluster of seven stars, not so close together as the *Pleiades*—may be seen. Of these *Aldebaran* is the name of the principal star, as *Alcyon* is the name of the brightest star in the Pleiades. Aldebaran is much larger than Alcyon, being of the first magnitude, while the other is only of the third.

with the sun in the centre, and the earth, at any point of the circle to be 95 millions away from him, and travelling round the sun once in the course of the year."

"And that circle, you say, sir, is 596 million miles round!" cried the boy, in utter bewilderment at the figures. "*That* must be a long way, indeed, for a million is a great number, I know."

"Yes, Owen," returned his tutor; "it's such a number, that supposing you were to set to work to reckon it up one by one, and to go on as fast as the clock ticks, day after day without any sleep, it would take you very nearly 19 years before you were able even to count the number of miles that the earth travels round the sun yearly."

"Indeed! indeed!" exclaimed the lad. "And the earth goes all that number of miles in one year?"

"Yes," replied the Captain. "But while the earth is doing this, it seems to stand still, and the sun, Owen, appears to make the tour of the constellations you see here in the direction of the arrows, travelling round them from *west to east* in the course of the year; so that, the circle being divided into 360 parts, he appears to do rather less than one degree a day; or, since each of the constellations consists of 30 degrees, he passes from one group of stars to the next every month. Now, lad, to make you understand how it is that the sun appears to travel round these stars every year in the *contrary*

direction to that which he appears to travel round our globe every day, let us suppose the earth to be at the sign of 'the Bull,' then, of course, the sun would be seen by us in the direction of the dotted line, appearing as if he was at the sign of 'the Scorpion.' But the earth travelling onward in the direction of the arrow would, in the course of time, reach the sign of 'the Crab,' when the sun would appear in the direction of the other dotted line over against the sign of 'the Goat'; so that while the earth was travelling in one direction along one half of the ecliptic, the sun would appear to move in the *opposite* direction along the *opposite* half. When, however, the earth reaches the sign of 'the Scorpion,' the sun will seem to be in the sign of 'the Bull'; and when the earth is at the sign of 'the Goat,' the sun, on the other hand, will seem to be at the sign of 'the Crab,' so that at this period the earth will be travelling in the apparent direction of the sun at the former period of the year, while the sun on the other hand will appear to move in the former direction of the earth; consequently, the sun's apparent motion round the ecliptic every year will be from *west to east*, or the *same* way as the earth travels round it, while his apparent daily motion will be from *east to west*, or *contrary* to the way the earth revolves on its axis. And now, Master Owen, you are not the sharp little fellow I take you for, if this matter isn't as plain to you as the mountain yonder."

"Oh! that it is, Captain Jones," cried the boy; "and whenever I look at the stars, I am sure I shall think of all you have said to me about them, and thank you for it too."

"Well, lad," added the Captain, "I've told you all about the earth now. You know how to measure it—how to tell where you are upon it—and how it's proved to be turning round and round on its axis at the rate of a thousand and odd miles an hour, though it appears to be standing still with us."

"But is it moving so quick as that, if you please, sir?" said the boy, still eager for fresh wonders.

"To be sure it is, at the equator," answered the Captain; "for didn't I explain to you that the earth had been found, by the most accurate measurement of the length of the degrees of latitude in different countries, to be exactly 7925 miles across the equator, and if it is that number of miles across there, it must be exactly 24,899 round. Then, again, if it's so many miles round at the equator, and revolves once every 24 hours, a common rule of three sum will tell us how fast it must go every hour; and thus we find that all things upon the surface of the earth at the equator must be travelling round and round at the rate of 1035 miles an hour at the least."

"Dear! dear! 1035 miles an hour!" echoed the lad; "and that's much, much quicker than the railway train goes, isn't it, sir?"

"Why, yes," smiled the sailor, "it would take

the quickest train—and that's the express, which travels at the rate, generally, of 45 miles in the hour—just one day to go as far as a tree, or a house, or a man does at the equator in one hour, and that even while they appear to stand still."

"And what rate are we travelling at in this room if you please, sir?" inquired the delighted boy.

"Well, you see," returned the old man, "the earth is spinning round on its poles like, as I said before, a huge peg-top leaning over on one side, and the parts where it's biggest round travel quickest, of course; while the rate of motion in all other places is according to their distance from the axis, or line connecting the point on which it turns. Now, as the equator is very nearly twice as far as we are from this same line running right down from one pole to the other, why it is plain that the parts of the earth there must travel very nearly twice as fast as they do here: so, as they are going at the rate of 1000 and odd miles an hour, we can be doing only about 580 miles in the same time."

"*Only* 580 miles an hour!" cried Owen, in utter astonishment at the fact; "and yet we seem to be sitting quite still here, sir, with the room and everything about us all steady too."

"Yes, as still and steady," added the Captain, "as if you were in the cabin of a large vessel, Owen. And what is the earth, lad, as I said before, but the good ship we're sailing in through the universe—

bound round the sun,—and going along so smoothly on her course that, as we sit here in one of the 'berths,' we are unconscious of there being any 'way' at all upon the vessel. On deck too, out in the open air, it's all the same so long as we keep our eyes on the parts of the ship itself; but immediately we look over the sides—and the horizon is but the gun'ale of our vessel—we see the blue tide of the great ocean around us go drifting by the ship, and sparkling with its million stars as the waters of the sea itself sparkle at night between the tropics."

"And is 580 miles an hour much swifter than anything goes in moving from one part of the earth to another?" inquired Owen, anxious to come at some more definite notion as to the rate he was being continually carried along.

"In a violent storm," responded the sailor, "the wind is reckoned to travel about 70 miles an hour; so you see the earth in these parts goes 8 times as fast as a gale of wind; but a cannon ball, at its greatest speed, flies at the rate of 480 miles an hour through the air; therefore you and I, and everything about us here, are constantly travelling through space nearly one fourth quicker than if we had been shot from the mouth of a cannon."

"Oh, goodness!" ejaculated the little fellow, "it's enough to take our breath away, Captain Jones, isn't it?—if we only felt it."

"But this is nothing at all, boy," proceeded the sailor, "compared with the rate the earth travels round the sun every year; for, you remember, I told you before, that the length round the earth's orbit —that is its course round the sun—is 596 millions of miles, and as the earth does this in the course of twelvemonths, you would find, if you calculated it, that it must be flying through space at the rate of rather more than 68,000 miles an hour, which is about 1000 and odd miles a minute. So you see the earth travels round the sun more than 60 times as quick as the surface at the equator travels round the earth's axis."

"More than a thousand miles a minute!" mused the wonder-stricken lad.

Owen's astonishment, however, was cut short by the Captain exclaiming, "But here's the dinner!" as the housekeeper entered to lay the tablecloth.

CHAPTER XIII.

THE SHEPHERD-BOY AND THE STARS.

ON his return home from the Captain's, Owen heard that his father had at length obtained a situation for him. Davy Evans had been over to Builth market that day, and having learnt there that farmer Powell on the Hills was in want of a lad to tend his sheep, he had agreed with the farmer that Owen should go to him upon trial.

The boy could think of little else that night; for, much as he wanted to be at work, now that the moment had come for him to leave home, for the first time in his life, the little fellow could hardly bear the thoughts of parting with all he knew and loved, and taking up his abode at a strange place, with strange faces about him; so he remained awake, wondering what kind of people "the Powells" were, and how often he would be allowed to go home, and whether the farmer was a kind man or not, and what would become of little Peggy and old Jack when he had gone. There would be no one

then, he thought to himself, to keep the boys on the common from throwing stones at the donkey, and no one to gather cob-nuts for his sister's squirrel, or to collect fresh moss for its bed. As the boy ran over all his sorrows at leaving home, his pillow grew wet with his tears, and the stars shone in at his window unheeded by him; for it was late in the night before he had wept himself to sleep.

As soon as Owen heard old Jack's bray at the kitchen door the next morning, he hurried down, and began telling the pet brute all his grief, as if it could understand and sympathize with him.

"So, my poor Jacky," cried the boy, as he took out to the animal a thick slice of bread and butter, well browned on the top with sugar, "you're going to lose your best friend, you are. Who'll put you your nice clean straw and houze you when the cold nights come, old fellow? Ah! Jack, you'll be left out on the common with the snow on the ground when I'm gone; for Hugh doesn't care a bit about you, as I do. But I'll speak to father, and ask him to think of you when the frost is very sharp and the wind's so keen it's like to blind one as it blows across the hills; though you're a knowing fellow enough to go under a hedge, if they *do* forget you. Then your coat, which I've got so clean and smooth now, will be left to go all wild, and I shall come back and find it as ragged as a beggar's, and all full of thistle-heads, I know; for father, you see, Jack,

has something else to do than to curry-comb you every day; so you 'll have to look after yourself then, old thing. But I tell you what, Jacky, if any of those boys try to tie any furze-bushes to your tail, do you kick out well behind, and that will frighten them; for they are only cowards that teaze gentle old things like you. People say you are obstinate, and will do only as you like; but let us try to make *them* go a way they don't want, and see if *they* 're not quite as stubborn as you are; and, would be worse, I dare say, only *they* can't suffer as *you* can. Why, I remember, Jack, before I was big enough to take care of you, the boys used to thrust spikes into you, and yet you wouldn't move a foot. Wouldn't they have run, though, if any one had served them the same way! Ah! you 're a brave old thing, you are, and can bear pain without flinching, and making a noise about it, as we do. I never thought I loved you, Jack, as much as I do; and I shall miss you—perhaps more than *you* will *me*—when I 'm away." And as he said so, the boy threw his arms about the creature's neck, and hugged him to him, while the fond animal rubbed his head against Owen's side as if he really understood all that had been said to him.

"Oh! Jack, Jack, I wish I could take you with me," cried the little fellow; "for I'm going to a farm house, and you 'd get plenty of beans and corn there; for I 'm sure you must be tired of that grass on the

common by this time. But, never mind, old pet; when I come home, I'll always bring you a pocket full of nice things, and *then* wont you be pleased to see me. But I must go now, Jacky; I've got my bundle of things to make up. I shall see you on the common as I go by, and be able to give you a last hug." And the boy squeezed the pet brute to him once more, the tears starting to his eyes the while.

Then suddenly turning from the animal, Owen closed the hatch, and proceeded to take a parting glance at his other pet, the squirrel.

Opening the door of the cage, he let the pretty little thing loose into the room, and seated himself in a chair while he watched the tiny creature run up his legs to get the nut he held out for it. As the squirrel sat upright on the boy's knee, holding the nut between its paws, and nibbling away the rind till the kernel was white and round as a little billiard ball, Owen chattered to it as he had previously done to Jack. "Ah! Skuggy, what will become of you, too, when I'm gone? Who'll give you your milk of a morning, sir; and who'll fill your cage with fresh moss; who'll give you nice bits of twig to gnaw, too, and watch you, as you peel the bark off, hold them up to your mouth, for all the world as if you were playing the flute? And who'll be here, then, Skuggy, to stop wicked little Peggy pulling your bed about, and making you angry;

for you can't bear any one to touch your moss, can you, little darling? But she likes to do it, to make Skuggy bark, and see him thrust his pretty little pink nose up to the bars. When I'm gone, too, Skug, you'll have no more balls of string to play with, and to pat from one side of the room to the other, like a little kitten, as you do; and if you nibble the things then, there will be nobody to take your part; and nobody, too, Skuggums, to tie your cage up to the window in the sun, so as you may sniff the nice fresh air every day; nor to whistle pretty tunes to you, and to watch you shake your bushy tail with delight at the music. No, poor Skug, you must shift for yourself when I'm away. You wont get a fresh bed then every week, as you do now; and you'll not he able to scratch away at the moss till you get it over your head, and make a ball of it all round you, you knowing little monkey. Ah! you're as pretty a fellow as ever skipped in the woods," went on the boy, as he rolled the squirrel over, and played with it in his lap, "with your little white stomach, there, like a clean pinafore before you. I'll bring him some nice big nuts and some pears to nibble at, every time I come home, that I will; and then he wont forget his old friend, will he, little beauty?"

But Owen's leave-taking with the squirrel was suddenly cut short by Davy Evans reminding the boy that it was nearly time for them to start.

Accordingly, the lad hastened to prepare his little bundle. While stowing his clothes away in the handkerchief, he looked up at the clock he had made, and, as he heard it tick against the wall, his eyes filled again with tears as he thought he was about to leave everything that was endeared to him for a place to which he was an utter stranger.

At length the hour for departure arrived, and Owen felt as you and I felt, lad, when we were of his age, that to leave for the first time the place with which all our affections were linked, was to make the world seem void and blank to us.

As he kissed his little sister Peggy, over and over again, the boy sobbed aloud. On meeting with old Jack, too, on the common, he hung upon the animal's neck, and pressed him to him, as though he was parting with him for ever; and when he and his father were fairly on their way, the road seemed to fly along as quickly as when we were in the coach returning to school after the holidays.

Davy tried to engage the little fellow in conversation by touching upon all the subjects that he knew were interesting to him, now asking him about what Captain Jones had told him concerning the earth—now talking to him about clocks, and then about levers and wheels and axles; but all to no purpose, for the boy's heart was too full to speak of things unconnected with his home; so giving the briefest

answers to his father's questions, he would immediately afterwards beg of him to look to old Jack of a winter's night, and to kiss Peggy for him, or else he would request him to go to Parson Wynn's, and tell them all there how suddenly he had been called away, and not to forget to see Captain Jones—for the old gentleman had been very kind to him,—and to thank him for the many things he had taught him.

Davy, noticing the boy's emotion, and himself half dreading the struggle at parting, told Owen that if he was a good lad, and would refrain from crying on his quitting him, he would buy him a box of tools next time he went to Brecon, and then he could make for himself any models he wanted.

Thus the journey passed, and the couple at length reached the farm-house ere Owen thought they had got half way there. And when the moment arrived for Owen to part from the last and dearest link that bound him with home, though the little fellow bit his lips to stifle his tears for some time, he was at length unable to bear up against it; so flinging himself on his father's neck, he sobbed outright with an intensity of grief that it is the lot of few of us in after life to feel. Nor was Davy himself unaflected by the boy's emotion, for as Owen curled his arms about his neck, and pressed his father to him, the tear drops might have been trickling down the old man's cheeks.

At length Davy Evans took his leave, and Owen stood at the gate on the hill, with his eyes dimmed with grief, watching his father's form grow fainter and fainter in the distance, till he lost sight of him altogether at the bend of the road, and then the little fellow felt his heart sink in his bosom, as if he were alone and unprotected in the world.

In a few days, however, the strangeness of the new home had worn off, and Owen got to find that the people whom he had come among were simple, kindly-hearted folk, who, in the primitive life they led, looked upon all about them as part of their own family.

The farm itself lay high on the mountains between Brecon and the Wye, and was some miles removed from any other habitation, so that the petty prides and distinctions of towns had not yet ruffled the peace of that humble homestead. The wife and daughter still wore linsey-woolsey, and broad-brimmed hats with large frilled caps beneath them, and stout leathern boots, instead of kid shoes and sandals. They were skilled in the manufacture of cheese and butter, and the curing of hams, and the brewing of ale—or "cwrw," as it was called in those parts, — while only the younger branches of the family, that attended the Sunday-school at the mountain church, could write their names, and that not very legibly. The dame her-

self could speak no English. The old man, however, from his continual attendance at the neighbouring markets and fairs, had picked up sufficient of the language to bargain with the dealers; though, like the generality of the country people in those parts, he made sad havoc with the genders and numbers when he attempted to talk "Saisnich," speaking of every male individual as *her*, and prefixing the singular article to all plural substances,—as, *a* trowsers, *a* gaiters, *a* braces, *a* shears, *a* snuffers, and *a* tongs.

Owen, with his little knowledge, soon became a small prodigy among the family; and when he communicated to them all he knew about levers and clocks, and told them what he had learnt from Captain Jones about the earth and the heavens, they grew to look upon the boy as somebody superior to themselves; so that the girls and the old farmer would like to get him in one corner of the settle of an evening, and listen to the boy as he talked to them about the stars, and told them how the earth was known to be round, and the many thousand miles it was through, and the wonderful rate at which it was travelling every hour. Nor was the old farmer himself the least delighted of the company.

At length Owen grew accustomed to his new home, and his mind being led back by his evening's

talk about the stars to the lessons he had learnt of the old sailor, he got, as the nights drew in and he saw the little specks of light twinkling above him as he folded the sheep, to notice more and more their places among one another, and to stay out later and later in the fields, gazing at the heavens, and wondering what the stars would be like if he could fly away to them? and what could be the use of them? and how far they were off?—and indulging in a number of like simple speculations.

Verily too the firmament, as viewed in the stillness of night from the mountain tops in those parts, was a sight to stir the dullest mind to admiration! There the sky could be seen resting, as it were, on the shadowy earth, and arching above it like the dim dome of some huge temple, and blue and unfathomable as the sea far away from land. Then as the eye vainly sought to plumb the depths of the vast aërial ocean, star after star came twinkling forth like a mass of crystal points sparkling in the light, as if the bed of the celestial sea were strewn with gems as thick as sand. In some parts, however, the eye rested on one star shining by itself like a dew-drop in a violet; in other parts appeared a cluster of many little ones, flittering in the darkness like a knot of fire-flies. Here were some set in the forms of glittering squares; there others ranged as brilliant triangles; and there some in circles, like jewels

round a crown; while in places might be seen a long line of light drops sparkling like water dripping from a fountain in the sun; so that the whole face of the heavens seemed powdered over with the infinite fairy forms of frost work. Then there was the broad luminous band streaming through the heavens like spray from the starry ocean and strewn so thick with its million orbs that the stars there were more like the silver dust from a butterfly's wing than an infinity of suns set round the girdle of the universe, with their beams so blended together that they seemed as if they were a wreath of phosphorescent mist floating across the heavens.

As the boy lay out on the hills watching the splendour of the firmament, his eye was at first bewildered by the multiplicity of sparkling points, and he could hardly distinguish form or difference among them. The lines they formed together seemed to be like a tangled skein to him, and he could no more pick out one from another than he could have recognised each particular grain in a sand-heap. All Owen knew as yet, was the figure of the Great Bear, and he delighted to run his eye from the two stars on one side of the square forming its body up to the little Pole-star. Then he would sit and look at this, thinking it was one of the ends of the universe, and wondering what he would see beyond it if he could only get up there, and what the earth would look like from that point.

When he had grown tired of such speculations, Owen would try to make out the form of the Little Bear itself, and though at first he could see only two bright stars, he found, as he looked on, others peeped out one after another, till at last he could distinctly perceive the whole seven shimmering through the darkness, and forming a similar figure, but reversed, to that of the Greater Bear itself.

When the shepherd-boy had unravelled thus much of the tangled web, he began to notice other forms in the heavens, and to perceive that the stars differed considerably in their sizes. As he ran his eyes along in a line with the two last stars in the *tail* of the Great Bear, he saw a very bright one, shining almost alone; and he wondered over and over again what name there could be for that.*

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* It is called *Arcturus* which, literally interpreted, signifies "the Bear's tail" (from αρκτος a bear and οὐρα a tail). This star is one of the first magnitude, and may always be found by continuing the eye in a line with the two last stars in the tail of the Great Bear. In former times it was probably regarded as a part of the tail itself (its name at least would seem to indicate as much), but at present it is considered as being in the skirt of the coat of *Boötes*, the husbandman—a constellation that was called by the Greeks *Arctophylax*, the bear-keeper (from αρκτος a bear and φυλαξ a keeper). The name *Boötes* (βοωτης, an oxherd) was given to this constellation because he was supposed to be the driver of the *Plough*—which is another name for the *Great Bear*, and the form of the seven principal stars in it certainly resemble the figure of a plough more than that of a bear. However, according as the one form or the

Then he tried to make out the shape of the smaller stars near this one, so as to see whether he could trace any resemblance in them to the form of any animal —but to no purpose; for the stars there seemed to go all kinds of ways to him. Accordingly, he shifted

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other presented itself to the minds of the early astronomers, so were the different names bestowed. Those to whom the seven stars appeared like a *Plough*, gave the title of *Boötes*, or the *Ploughman*, to the constellation next to it; while those who fancied these seven stars to resemble a *Bear*, christened the adjacent constellation *Arctophylax*, or the *Bear-keeper*. Fable relates that *Ceres*, as the reward of *Philomelus* for the invention of the art of ploughing, transferred him and his oxen to the heavens under the name of *Boötes*. According to some, the Great Bear is *Calisto*, an attendant of *Diana* (the moon, and in fable the twin sister of *Apollo*, the sun) who was considered the goddess of hunting, probably from such expeditions having been first carried on during the night. *Calisto* was termed an attendant of *Diana*, doubtlessly because the constellation of the *Great Bear* is one that never sets in the northern hemisphere. It seems probable that *Calisto* was also the original of *Acteon*, who, according to the ancient myth, was changed into a stag, and torn to pieces by dogs, for discovering *Diana* bathing. The astronomic explanation of this would be, that the moon was shining on the water whilst the constellation *Calisto* was, as usual, above the horizon—that this constellation was afterwards changed into a Bear, or some such animal—and that the Bear was continually pursued by the *Canes Venatici*, or hunting dogs, which is the next constellation, to the east of it, and which consequently appears to be always following the other. The same seven stars which are called the *Great Bear* by some, and the *Plough* by others, are also termed *Charles' Wain* (or wagon) by many. The four stars being supposed to represent the four wheels of the vehicle, and the three other stars extending from these to be the horses. This accounts for the name of *Auriga* (the wagoner) being given to another constellation close to the *Wain*.

his eye from this to the opposite quarter of the heavens, and on the other side of the Milky Way he beheld another set of seven stars, all of the same size as the brighter ones in the Great Bear, and forming almost the same figure among themselves. There was the same kind of square, and three stars extending in like manner from one corner of it, but in an opposite direction to those in the tail of the Great Bear, and at greater distances apart, while the square itself was larger.*

The boy was greatly delighted to find that he

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* This square consists of four stars of the second magnitude, *three* in the body of the constellation *Pegasus*, and *one* in the head of the constellation *Andromeda*. It may be found by looking to that side of the Milky Way which is directly opposite to the one on which the *Great Bear* is seen. Then if the tail of the Great Bear be pointing downwards to the North, run the eye from the corner of the square in the constellation Pegasus nearest the Milky Way *up towards* the south, and three other bright stars will be seen extending from this point—two between it and the Milky Way, and the third in the Milky Way itself. The two stars lying between the corner of the square and the Milky Way, are in the constellation *Andromeda*, and the third, (which appears in the Milky Way itself), is situated in the constellation *Perseus*. According to the Grecian fable, *Pegasus* sprang from the drops of blood which fell from the head of the Gorgon Medusa after Perseus had decapitated her. Hence all these constellations are found to be connected in the heavens. *Medusa's Head* is near *Perseus*, who is situate in the Milky Way while Medusa is on one side of it, towards *Pegasus*. It is fabled that the Gorgons—of whom Medusa was the chief— had but one eye, and in Medusa's head there is *one* bright star of the second magnitude, called *Algol*. The bright stars in the body of *Pegasus* are known by the names of *Scheat*, *Markab*, and *Algenib*.

could reduce some of the vast crowd of stars into definite order, so as to be able to recognise them on looking again to the same part of the heavens.

"Oh! I see," cried the little fellow, as he sat on a rock at the hill-top, "it's very difficult at first; but after a time I shall get to know them all; for I notice that the stars seem to be crowded thicker and thicker together as they get nearer to the Milky Way. Over by the Great Bear, there appear to be but few large ones, and as I run my eyes along the bright band, I can see them sparkling away in it and on each side of it, as thick as bees about a hive. Look, too!" went on the boy, "the Milky Way seems to cut the heavens in two, and to come up from one side of the horizon, and to stretch right across to the other, where it opens, and has two branches to it, like the top of the letter Y.* Now, I'll go right along the Milky Way, and notice all the bright stars I can find in it and on each side of it, beginning at the end where it is divided into two streams. Well, first I see, as I run my eye up along one of the branches, three stars, with a bright one in the middle, and these are just on one side of the branch that is farthest from the

* The two branches of the Milky Way are never seen towards the north by us. They generally rise towards the east and set towards the west. They should mostly be looked for towards the south. Occasionally, however, they are not visible, being below the horizon.

Great Bear, but a good bit below where the two streams meet.* I shall know those again, I am sure," continued the boy, musing to himself. "Then, as I go on and get closer to the fork of the Milky Way, I can see one—two—three—yes, five stars in the form of a cross-bow, with a bright one at the head of the bow.† These stars are in the branch of the Milky Way nearest the Great Bear. And look," he cried, "just on one side of these, towards the Bear itself, there's a very large and bright star —one of the brightest I've seen, indeed—with three little ones close beside it, and the whole four are

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* The bright star in the middle of these three is called *Altair*, and is situated in the constellation of the *Eagle*. It is of the first magnitude, and is never seen in the north by us; rising nearly due east, and setting nearly due west, and appearing, when in the south, almost as high above the southern horizon as the Pole-star is above the northern.

† These five stars are the principal ones in the constellation of *the Swan*. The form which the boy fancies to resemble a cross-bow, the ancient astronomers thought to be like a long-necked bird flying with outstretched wings. One of these stars —the farthest from the fork of the Milky Way, and which is in the beak of the Swan—is celebrated as being the one of which Bessel discovered the parallax—and the first fixed star whose distance from the sun was accurately measured. The brightest star of the five is near the tail of the Swan, and of the second magnitude, whereas that in the beak is of the third. This constellation may easily be found by looking at one of the branches near the fork of the Milky Way, when three bright stars will be noticed directly in a line with the Milky Way itself, and two others reaching across it from one branch to the other.

arranged something in the form of a harp.* Then, as I go on and get close to the point where the two streams run into one, I can see again three stars, not quite in a line with one another; and these are between the Great Bear and the Milky Way.† Oh! it isn't so very difficult after all, I see, to tell the stars when you set about the work properly. Now, as I go past the point where the two streams of the Milky Way are joined into one, I can see at a little distance beyond it a cluster of stars arranged, I do declare, in the form of a chair, with a bright one at the back; and these stars are nearly all in the Milky Way itself; while the chair seems as if it was placed across it.‡ Next, as I go on along the

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* This bright star is known by the name *Vega*, and is one of the most beautiful in our hemisphere. The constellation in which it is situate is called "*the Lyre*," though it is more like the form of an ancient Welsh harp than the horse-shoe shape which we connect with the more classic instrument. The three other stars in this constellation are of the third magnitude. *Vega* may be easily discovered on directing the eye a little beyond the fork of the Milky Way, and looking a short distance on one side of the branch nearest the Great Bear. The constellation of the Lyre is beside that of the Swan, and between it and the Bear, so the one being found will lead to the other.

† These three are in the constellation *Cepheus*. They are all of the third magnitude, and lie nearly midway between the square of the Great Bear and that of Pegasus, being on the side of the Milky Way nearest the Bear. They never set, and must be generally looked for towards the north. They are easily distinguished, from their being almost in a line with each other.

‡ This constellation is known as "*Cassiopœia's chair.*" The

Milky Way, and get farther from the branches, I can see a big star sparkling in the middle of it. But that's the last of the three I noticed before projecting from the large square opposite to the Great Bear. Going past this, I catch sight of a very big bright one, as big as the one I saw in the harp; but this star is a little distance out of the Milky Way, on the side towards the Great Bear. And, now I look again, the others about it take the form of a hay-stack, with the top pointing towards the Great Bear itself.* Oh! dear, how beautiful," cried the delighted boy. "As I keep on running my eye down the Milky Way, too, I can see two more large bright stars, one as big as any I've seen, and a little distance from the side, towards the Great

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stars in it are mostly all of the third magnitude. Cassiopeia, it will be remembered, was, according to the ancient fable, the wife of King Cepheus and the mother of Andromeda, whose husband was Perseus. Hence we find all these constellations intimately connected in the heavens. On the side of the Milky Way, nearest the Great Bear, is Cepheus; then at a little distance from this, and in the Milky Way itself, comes Cassiopeia; while farther on in the Milky Way is Perseus, with Andromeda, who is on the opposite side of the galaxy to Cepheus, and between Cassiopeia and Perseus.

* This is the constellation of the *Wagoner*, or driver of the *Wain* or wagon (the name sometimes given to the Great Bear). The bright star is of the first magnitude, and known by the name of *Capella*. It is situate in the left shoulder of *Auriga* (the wagoner). This star is close to the side of the Milky Way, towards the Bear, and has another star near it of the second magnitude.

Bear; the stars near these seem to be arranged in a figure something like the gable end of a house, standing on the Milky Way itself, with a bright star at one of the lower corners of it, and the two other bright ones at the top forming the back of the roof, as it were. Then, directly opposite these, some little distance from the other side of the Milky Way, there's another big star, I declare, with a number of little ones about it in the form of the letter V, the big one being at top of one of the prongs of the letter. I'm sure I should have taken them for the Seven Sisters, Captain Jones told me about, only they don't seem close enough together. Oh! no; there are *the* Seven Sisters, sparkling away like a knot of little glow-worms in the dark. This must be the Bull, then," exclaimed Owen, after thinking awhile; "for I remember Captain Jones said the 'Seven Sisters,' or Plei—, what did he call them? Ah! 'Pleiades,'—that's it—were in the Bull's neck. So the other group of little stars must be what the Captain called 'the Hyades.' And the big star there at the top, on one of the prongs of the V, must be the one he called 'Aldebaran'. Yes, that it must! I've found out all this, by myself, too. Why, this must be the ecliptic, then; and the sun, and moon, and planets must all travel along near this line. I wish the moon was up," continued the little star-gazer; for then I could make sure whether I was right or not.

Those stars, too, on the other side of the Milky Way, that seemed to be like the gable end of a house, must really be the constellation of the Twins; for I remember when Captain Jones showed me the map of the Zodiac there were two bright stars, one in the head of Castor, and the other in the neck of Pollux, and a third in one of their feet. Yes, I'm right; I'm sure I am."

Owen turned to gaze at the Milky Way once more, and as he looked a little below the bright star in the foot of one of the Twins, his eye was arrested by a very brilliant constellation close on the other side of the galaxy, and consisting of four large stars, arranged in the form of a square, with three more, very near together, and placed in a slanting direction in the middle of the others. Two of the stars in the square were of the first magnitude,*

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* This is the constellation *Orion*, and the two stars in it, which are of the first magnitude, are known by the names of *Beltegeux*, and *Rigel*. Beltegeux is at the corner of the square nearest the Milky Way, and Rigel at the cross corner farthest from it. The three stars in the middle of the square constitute "*Orion's Belt.*" Orion never appears towards the north with us. He rises as nearly as possible due east, and sets due west, attaining but a slight elevation above the southern horizon. The equinoctial line passes very nearly through the upper star in the belt of Orion, and hence this star is almost on a level with the equator of the earth, so that at its greatest altitude we can estimate the height of the equator above the horizon in the same manner as the height of the pole may be reckoned by the Pole-star. When Orion comes to the meridian, the most brilliant of the constellations are above the horizon, the *Great Dog* and *the Lion* then becoming visible. At this period we are said to have

and all the others of the second; so that the whole appeared to Owen to be the most brilliant constellation he had yet seen. "Then on the other side of the Milky Way, and opposite to the square with the three slanting stars in the middle of it," the boy went on, "I can see two more stars, the first a very bright one, and the second dimmer than the other, arranged in a slanting line with one another, and the brightest farthest away from the Great Bear."*

Delighted with the discoveries he had made, the little astronomer continued for some time glancing from one constellation to another, so as to impress their forms upon his mind; then he began count-

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the most splendid view of the celestial bodies that the starry firmament affords. The constellation Orion is of great antiquity, being frequently mentioned by the sacred writers. Job alludes to it as follows:—"Hast thou an arm like God? or canst thou thunder with a voice like Him? Gird up thy loins and declare! Canst thou bind the sweet influences of the *Pleiades*, or loose the bonds of *Orion*? Canst thou bring forth *Mazzaroth* in his season, or canst thou guide *Arcturus* with his sons?" And again in the book of Amos (said to have been written by a shepherd 800 years before the Christian era) there occurs the following passage: "Ye who turn judgment to wormwood, and leave off righteousness in the earth, Seek Him that maketh the *Seven Stars* and *Orion*, and turneth the shadow of death into the morning, and maketh the day dark with night: that calleth for the waters of the sea, and poureth them out upon the face of the earth: The LORD is his name."

* These are the principal stars in the constellation of the *Little Dog*, which, according to the fable, formed one of the beagles of Orion's pack. The name of the large star in the constellation is *Procyon*.

ing how many stars of the first magnitude he could see; and, after some little trouble, he came to the conclusion that there were only nine visible to him.* Next, the boy wondered, as he watched some of the

* The stars of the first magnitude seen by the boy were as follows:—1. *Altair*, in the Eagle; 2. *Vega*, in the Lyre; 3. *Arcturus*, in Bootes, the Shepherd; 4. *Capella*, in the Wagoner; 5. *Castor*, in the Twins; 6. *Aldebaran*, in the eye of the Bull; 7. and 8. *Beltegeux* and *Rigel*, in Orion; 9. *Procyon*, in the Little Dog. But besides these, there are other stars of the first magnitude, which become visible in the apparent revolution of the heavens; these are, 10. *Regulus*, in the Lion; 11. *Spica*, in the Virgin; 12. *Antares*, in the heart of the Scorpion; and 13. *Sirius*, in the Great Dog, commonly known as the Dog-star. The two last attain but a slight elevation above the southern horizon, towards which quarter they must always be looked for. *Sirius* is the brightest of all the fixed stars that are visible to us. Indeed, the Great Dog is one of the most splendid constellations in the heavens, consisting of four stars of the second magnitude, and one of the first, and arranged somewhat in the shape of a truncated wedge standing up on end. The Great Dog is fabled to have been one of Orion's hounds. Some consider Sirius to represent the dog worshipped by the Egyptians as the god "*Anubis*," and the Egyptians certainly believed the Nile to be under the influence of this star, which is vertical on the 30th June, when that river overflows. The dog-days are so called because the great heat at this period is ascribed to the influence of the dog-star, which rises with the sun during that time—viz., from the 25th of July till the 24th of August. According to the data of Henderson, Sirius is sixty times more intrinsically brilliant than our sun; that is to say, were the sun removed to the same distance from us as the dog-star, it would appear sixty times less bright than Sirius. The stars of the first magnitude above mentioned, are many of them of different colours from the others. For instance, *Altair*, *Vega*, *Spica*, and *Sirius* are all *white* stars (though Sirius was celebrated by the ancients as a *red* star); *Aldebaran*, *Arcturus*, and *Beltegeux*, on the other hand, are *red*, while *Capella* and *Procyon* are yellow.

stars set behind the western hills, and others rise gradually into sight in the east, what fresh constellations would come into view as the night went on. So he determined to get up long before sun-rise some morning, and see what other stars he could distinguish then. After this, Owen noticed that the stars in the *north*, as Captain Jones had told him, only just grazed the horizon, and never sank below it, remaining always in sight; whereas, those in the extreme *south* rose but a short height above the horizon, and continued visible but for a little time; while some that he had observed to be rising in the east when he began noticing them that evening, had since taken a slanting direction towards the south, and were now high above the southern horizon. The boy was greatly pleased to find all the Captain had told him prove so true; and he sat for some time endeavouring to make out the different circles that each of the stars described in its apparent tour of the sky. It was late that night before the little star-gazer reached the farm.

Owen could think of little else than the stars, now that he had once begun to observe their figures and their motions, and he longed to know more about them. Accordingly as he sat out in the fields all day, minding the flock, he busied himself with devising some means of measuring the distances the orbs were apart, so that he might be able to mark down the figures they made with one another in the heavens.

This occupied the boy's mind for some time, till at length it struck him that by means of some beads on a string he might be able to arrive at the desired result. So after a few rude experiments on the matter, he took some pieces of wood out with him to the hills, and as he sat tending the sheep he amused himself by fashioning them into an apparatus for the purpose. This he formed something after the shape of the instrument used for counting, called an "abacus;" for there was a frame to it, across which stretched a number of threads with beads to slide along them, and some six inches in front of these was placed an upright piece of wood with a sight-hole at the upper part of it, in order that the eye might be kept in the same position; so that when the boy had put the whole together, it assumed the form represented in the subjoined engraving.

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OWEN MEASURES THE DISTANCES OF THE STARS.—Page 393.

The rude apparatus once finished, Owen betook himself to the hills night after night, and there lay stringing his beads on the threads till he got them to arrange themselves in the form of the principal stars in the constellations he had noticed. To do this, however, cost the little shepherd astronomer no slight trouble, for when he had shifted one of the beads upon the string till it cut the largest star in the group, and he came to slide along the other beads, so that they should be in a line with the rest of the stars, he often found that as he moved one he displaced the others. But Owen, once bent upon the purpose, was not to be beaten by a few difficulties, so he tried on and on, until at length he got to be able to arrange the beads near enough to the forms of the stars to satisfy himself; and this done, he proceeded to mark down roughly upon the paper that he kept beside him, the figures of the principal constellations, one after another, as he measured them.

The boy had soon made sufficient progress in his work of mapping down the heavens to be able to show his "star-papers," as he called them, to farmer Powell, who was so astonished at the little fellow's labours, that he set him to some light work in the barn, and put another lad to look after the sheep, so that Owen might have time to copy out by day the rough figures that he had sketched at night. And often, when the little fellow was engaged

winnowing, the good old farmer would come to him in the barn and turn the machine himself, while the boy sat by his side drawing his plan of the stars, and chattering to him the while about their movements and sizes and figures; telling him too, that Captain Jones said the fixed stars were millions and millions of miles away from the earth, and how they all appeared to be moving round one fixed point, which was called the pole of the world; and how, too, it was by measuring the altitude of that point above the horizon, that sailors were enabled to find their way across the sea, where there was no other mark to guide them. All this so amazed and delighted the simple-minded farmer, that he would creep away to the barn to do the boy's work at every opportunity. Nor did he fail to express his admiration for the little fellow to his daughters, declaring "that *her* was the most wonderful boy in the world, and it was a shame such a scholard as *her* was should be a shepherd, for *her* knowed more than many an old man with *a* spectacles on *her* nose."

Thus Owen grew to be an especial favourite at the mountain farm, and often he was gravely consulted as to whether he could not find out by the stars where the colt had strayed, or where the hen hid her eggs, or whether the Scotch tea-man had really carried off the silver tea-spoon they had missed last time *her* came round, and a host of such other

family mishaps. As the nights began to draw in and to grow chilly, the girls too, when they found Owen staying out late on the hills, would carry him a blanket to wrap himself in and keep the damp from "striking inwards," as they termed it. Sometimes, too, they would sit by his side wondering, as they watched him at his work, and get him to tell them something about the brighter stars that took their fancy for the moment.

One night, after the girls had left him, and the little astronomer lay on one of the crags observing the form of the stars in the constellation of Cassiopæia's Chair, he was startled by a loud sound that seemed to him like the noise old Jack used to make as he and his father returned late at night across the common at Llanvach. Immediately Owen's thoughts were turned from the stars towards home and his favourite brute, and he wondered whether the poor thing was out in the cold then—for the wind was blowing sharp across the hills—and whether——

The boy's train of thought was suddenly interrupted by the same sound bursting on his ear, and, now that it was nearer, it was more like old Jack's bray than ever.

"It must be some poor brute that has gone astray," thought Owen; and the boy stood up to look across the hills and see if he could distinguish the form of any animal in the distance. But the

earth was like a dark shadow, and he could make out nothing but the black tops of the mountains as here and there they rose like dark waves one above the other. Then he put his ear down to the ground, and listened whether he could catch the sound of any hoofs pattering on the stones.

After a few minutes he started to his feet, crying, "Yes! I can hear something coming across the hills;" so he peered once more into the darkness, and tried with all his might, as he looked in the direction whence the sound had come, to catch sight of the animal. Owen thought, as he strained his eyes, he could make out some black mass in the distance. Still he half doubted whether what he saw might not be one of the lumps of rock projecting through the mountain's side.

Again the boy put his ear to the earth, and again he was convinced that the animal was coming towards him.

"Poor thing!" exclaimed the lad, "it must have strayed a long way, wherever it has come from, for there's no cottage near for miles round. Perhaps it's lost its foal. I'll stop quite still here, and when it comes up I'll take it back with me to the yard, and make it up a nice bed in the stable till the morning. I shall like it for poor old Jack's sake, for he was always so fond and thankful for anything I did for him."

A short time elapsed, and Owen, who had been

still looking into the dusky distance, cried, "Yes! I can see it *plainly* now. It's coming straight towards me, but there's somebody on its back. What *can* it mean? What can any one want out at this hour, and taking such a road as this?"

Presently, as the wind blew across the hills towards the approaching animal, another loud bray pierced the stillness of the night, and the lad gave a start back as he exclaimed, "*That's* my old Jack, I'm sure!" and once more the little fellow looked towards the creature, to assure himself he was not mistaken. "I'm sure it's Jack. Oh, they've stolen him, they have," cried Owen, as the tears streamed down his eyes. He's been left out on the common, and the gipsies have got hold of him, I know. And what can *I* do here alone against one of those wicked fellows. But I'll have a struggle for it; they sha'n't take my old Jack from me if I can help it. He knows I'm here, for, hark! how quick he's coming now. Yes, he knows it as well as he used to, when I was coming over the common, long before he saw me. He sha'n't be taken away to be ill-treated, I'm determined."

Owen crept behind the rock, and armed himself with a large stone, as he watched the figure draw nearer and nearer towards him; then peeping out from behind the edge of the crag, the boy muttered to himself, "The fellow is taken with the lights at the farm yonder, for he keeps his head

turned that way; so as he goes by I'll spring out upon him unawares and throw him from his seat, and then jump on old Jack's back and be off. Yes," continued Owen to himself, as he drew his breath quicker and quicker, "the fellow still keeps his head turned from me. Hush! here he comes, and now is the time."

It was but the work of a moment for Owen to dart from his hiding-place. With a bound towards the rider, he was about to fling him to the ground, when Jack wheeled suddenly round towards his little master, and so in a measure warded off the force of the blow. The rider, finding himself thus unexpectedly attacked, turned round in his seat and seized Owen by the collar. As he did so, the little fellow shrieked, "It's John Jarman, as I live!"

"What, Owen?" cried the blacksmith's boy, at the same moment, "I thought you were over at the farm yonder, and I was looking at the lights there, wondering which was yours."

"Come, Master John," said Owen sharply, as the fond animal rubbed his head against his side, "what business have you with my Jack here. You haven't turned thief, have you, and taken him away without asking?"

"Thief, Owen!" shouted the boy. "I'm not in a humour to bear that kind of talk, I can tell you.

If it *is* your animal, I thought you were friend enough that I could borrow it of you without asking."

"Borrowing without asking," replied Owen, angrily, "is what I call stealing."

"Do you?" shouted the other, "then take that!" And as the young blacksmith said this, he levelled a heavy blow at Owen. At the same moment, however, old Jack, anxious to get rid of his load, bent down his head, and kicking out his heels, sent young Jarman—who, in the attempt to strike the little fellow, had lost his seat on the animal's back—flying over his head.

John Jarman fell heavily against the crags, and lay stunned by the fall.

Owen stood almost paralyzed with fright, as he saw young Jarman stretched senseless on the ground, and he thought at first, in his alarm, that the boy had been killed on the spot. A thousand fears rushed instantly through his brain. He was alone there in the dark, and what should he do with him, and how should he ever be able to make out to the people that it was no fault of his. Then he remembered how sadly the poor fellow had been treated at home, and, as his heart relented, he went towards the boy, crying as he knelt down beside him, "John, John! speak to me! Oh, *do* speak to me! Open your eyes and look at me, John. We said we had made it up

at Parson Wynn's, and don't let us quarrel again. You may have Jack; I'll give him to you if you'll only promise to be good to him."

The blacksmith's boy looked up in Owen's face, and said faintly, "It served me right. I've had blows enough myself, without wanting to give you any. But I was angry, Owen. Father's been at his old tricks. There, I'm better now, thank you. It was a heavy tumble though; it shook me all to pieces like. Father came home drunk again and dragged me out of bed a few hours ago and thrashed me, in my night-gown as I was, till I was nearly mad with the pain; so I seized my clothes and ran away, and there's an end of it now, for I'll never go back—*never*. I didn't hit you, did I, Owen?"

"No, no, John," replied the boy, "and I should have thought when I saw you in such a place as this, and so late at night, that something had happened to you at home. But where are you going to, John? and have you got any money to carry you on the road?"

"I've got a little," answered Jarman, sullenly. "I sold a fish I caught a few days ago. But what's to become of mother now I'm gone troubles me. Father's *very* wicked—there's no other word for it, Owen—and he knocks poor mother about as well as me. When I was at home I *could* stop him harming *her* a little; but now he'll do as he likes with her. He's finished with *me* though, for I can't stand it any

longer; so I'm off to Bristol to get a ship. I only wish I'd gone before, when I was up at Mr. Wynn's. I'll send the donkey back by the wagoner, Owen, when I get to Brecon. You needn't be afraid about him."

"No, no, John! but wont you come and stop the night at the farm," inquired Owen, kindly; "they're very good people, and I know they'd let you stay with me."

"That wont suit me, Owen," said the blacksmith's boy; "I should have some one keeping me back, and persuading me to go home again, like a fool. But now I'm off for good—or bad—I hardly care which. Good bye, Owen, I'll come and see you if I ever get safe back again."

"But stay a minute, John," said his little companion, as he fumbled in his pockets; "I've got a shilling or two here. One father paid me for the clock I made, and one Captain Jones gave me. Do you take them, they'll help you on your way."

"You're a good little fellow," said young Jarman, as he held out his hand; "they *will* be of use to me, Owen, and when I come back from sea I'll give them to you again, and I'll bring you some nice present from abroad for the loan of them. Ah! I was foolish ever to quarrel with you; but you see everybody in the village used to tell me, when I complained of father's treatment, that I should strive to be like you. They would say, see what a

good lad Owen Evans is, until I was sick of the name of Owen Evans. But we're friends now, Owey, and if I don't go to the bottom of the sea, and can do you a good turn in after life, why you may depend upon it I *will*, and be glad of the chance, too. Good bye, Owen," and the blacksmith's boy, as he mounted old Jack once more, stretched out his hand to Owen Evans, who threw his arm round his companion's neck and hugged him to him as he echoed the other's words, "Good bye."

A few minutes afterwards young Jarman was forcing the donkey onwards towards Brecon, while Owen, with his eyes full of tears, stood on the crag watching the two disappear in the darkness.

CHAPTER XIV.

THE BOY TAKES HIS STAR-PAPERS TO THE ODD OLD SQUIRE AT THE OBSERVATORY.

Owen was some little time before he could get the thoughts of young Jarman out of his mind, and he kept wondering where poor John had got to—and whether his money was all gone—and how he would live when it was at an end—and how, too, he would miss the comforts of his home, bad as he thought it. But, boy-like, Owen in a few days had sufficiently forgotten the scene on the mountain to be able to continue his little chart of the heavens, and the praises of the old farmer made him so pleased with the work, that he grew to long for its completion.

At length, what with staying out late and rising early, the little shepherd had transferred to his humble map the figures of all the constellations that were visible at that part of the globe. When, however, he had brought his labours to an end, the plan, owing to the boy's ignorance of perspective,

was far from being an accurate copy of the heavens; for not only had the boy drawn the forms of the different constellations separately, and had no idea of grouping them into a whole, under one point of view, but having copied the figures of the stars at different periods, had blended together the constellations that were and were not visible at the same time, so that when they were all spread out together on his chart, the line that bounded them was anything but that of the horizon. Nevertheless, it was a wonderful performance, rude asit was, for a self-taught lad, and had cost him no little trouble to get the several constellations into their right places one with another.*

As, however, it would be impossible to convey to the reader a correct notion of the places of the stars by a literal transcript of the shepherd-boy's star-papers, the following engraving has been made to represent a view of the constellations that appear above the horizon in our latitude, at the period

* The construction of these star-papers is no fable. The shepherd boy Ferguson delineated them by sliding beads on a string, and rude as they necessarily were, still, regarded as the work of a mere boy, and one too who was comparatively uneducated, they were considered by all who could appreciate them as the emanation of no ordinary mind. Neither is the circumstance of the old farmer doing the boy's work at the farm, while the little fellow copied out his plan of the stars, in the least apocryphal. Ferguson, in his autobiography, narrates the incident, adding, "I shall always have a respect for the memory of that man."

when *Orion* is crossing the meridian, and when the best view of the heavenly bodies is to be obtained.*

The little chart once finished, the boy grew anxious to let his father and old Captain Jones see what he had done. Nor was the simple-minded farmer less proud of the work than Owen himself, and he took especial delight in making the lad exhibit the map to every one that came—no matter whether on business or pleasure—to the farm, always taking care at the same time to impress on

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* This map is intended to give the reader merely a *rough* notion of the places of the principal stars in the firmament. For the sake of simplicity few of the stars beyond those of the third magnitude have been inserted, and it should be borne in mind that the map will serve only for the nights during the months of December, January, and February. Orion comes to the meridian at about midnight on the 10th December, and just upon two hours earlier every succeeding month; that is to say, at about 10 o'clock at night on the 10th January, and at about 8 o'clock at night on the 10th February. It has been before explained that a sidereal day is very nearly 4 minutes shorter than our ordinary clock-day, or, in other words, that the same star crosses the meridian every 23 hours 56 minutes. Hence for each day after the 10th December 4 minutes must be subtracted from 12 o'clock at night. Suppose, for instance, we wished to know at what hour Orion would come to the meridian on the 21st January, then, as this is 41 days after the 10th December, we must multiply 41 by 4, and that gives us 164 minutes, or 2 hours 44 minutes for the time to be subtracted from 12 hours 0 minutes; so that we thus find this constellation would cross the meridian then, at about 16 minutes past 9 in the evening.

the people that "*her* was a most wonderful boy." Consequently, Owen had little or no difficulty in obtaining leave of the farmer to go home for a day or two, so as to show his star-papers to his friends.

When Davy Evans looked upon his boy's work, the poor man was deeply affected by it, for he could not help feeling the bitterness of the lot that deprived him of the means of fostering a talent that promised, if properly cultured, to yield such noble results; and as he hugged the little fellow to his bosom, he grieved over his sorry fortune till the map was spotted with his tears. The labourer was saddened to think how pitiful it was that a boy with a mind like Owen's should be forced to get his bread by the labour of his hands, and—though Davy generally bore his humble lot in life with sufficient heroism to be contented with it—now, however, he could not refrain from contrasting his fortunes with those who had been more favoured in life, and wondering why he should have been given a son, with a mind that only wanted tuition to take rank among the most intellectual, when he was denied the means of educating him. The poor man could not help thinking of the well-to-do squires round about him, and how little their children seemed to be conscious of the benefits that had been heaped upon them, deeming it even a drudgery to have the stores of wisdom opened to them; while others, less lucky than

themselves, felt the want of the means to acquire any knowledge to be the most bitter of their privations.

At length Davy Evans told Owen that he was but a poor judge as to the merits of his work, and that he had better carry his map to the Captain, from whom he had already learnt so much about the stars and the earth; for the old gentleman would be able to understand it better than he could. The boy was delighted at the opportunity of visiting his old friend once more, and hastened to do as his father had directed.

On reaching the cottage, Owen was grieved to find the old sailor ill in bed, and he would have returned at once, had not Mrs. Pugh told him that she knew the Captain would be vexed if he did so; for her master had been talking of Owen ever since he had gone to the farm; and only that very morning he was wondering if he should ever see the boy again. Then the housekeeper lifted up her apron, and wiped her eyes with the corner of it, as she informed Owen that she "was afeard her poor dear master was a-breaking very fast, and that he would never see the winter out;" adding, "that he was as good a master as ever wore shoe leather. And what was to become of her when he, poor soul, was gone, was more than she could say."

Presently, Owen was ushered into the little bedroom, and there he found the old man with his

white hair streaming on the pillow, and the mantel-piece crowded with physic bottles.

The boy shuddered as he entered, and he walked stealthily towards the bed, fearful of disturbing the old man, if he should be dozing.

But the invalid had heard the door creak; and turning in his bed as Owen approached, he stretched out his veiny hand to him, saying, "I'm glad you've come to see me, youngster,—*very* glad;" and he pressed the boy's palm as warmly as he had power to do in his own. "But Mrs. Pugh isn't with you, is she?" inquired the old sailor in a half-whisper.

Owen informed the Captain that he was alone with him in the room; and, as he did so, the boy held his star-papers behind his back; for he was unwilling to trouble the invalid upon any such matters, weak as the old gentleman then appeared to be.

"I'm glad she's gone," said the Captain; "for I can't bear the sight of that woman. She haunts me with her carneying, hypocritical voice. She thinks I've a little money to leave, and is like one of the sharks that follow close in the wake of a ship whenever there's a chance of a death aboard. If it wasn't, Owen, for your little sister Peg, I should be without a thing to love in the world; and she's a little bit of truth, bless her. There's no wheedling about *her*, Owen, — no thoughts of

legacies to come—ugh! It would be better to die the death of a pauper; for those about you then would at least be honest. But Mrs. Pugh fancies I've got some money to leave, and is always worrying me to make my will, saying, we never know when we may be cut off—hang her! I'm well aware I've not long to live; but what does she want continually croaking of death to me? I'll foil her, though, *that* I will. You're sure she's not listening outside the door. Go and see, lad; for if she heard me say as much, I shouldn't be able to get a thing from her. Ah! boy, it's sad work," said the old man, sorrowfully, "to be obliged to end your days without a soul about you, but those whose services you pay for; and who, you think, are waiting for your last gasp, for what it shall bring to them. There's no one but little Peg that I love and can trust in the world; and she's like a little creature fresh from the heaven I hope to go to,—with her beautiful laugh, as full of truth and happiness as the voice of the lark itself. But you see, lad, when we get old we grow suspicious; the blood gets chilled; and I'd give the world to be like you, now, Owen with a whole life before me, and all my actions to do over again. Ah! what fine things I'd do *then*, boy. So, do you profit by me, and not come, as I do, to look back on your life in your old age as a waste of years, and to see what you *might* have done, and how little

you *did*. But all this is sad work for you, Owen; so come, tell me what you have been doing since I saw you last. You never came to wish me good bye, though."

"Sir," said Owen, "I had to leave in such a hurry; and I asked father to call and thank you for all your kindness to me."

"I know you did, boy," answered the old man, as he squeezed Owen's hand again in his; "and I felt it *deeply* at the time. But at my age we are apt to expect more attention than we have any right to meet with. We get selfish—wretchedly selfish, lad, and think everybody should give place to us. I forget, too, that people like you have their living to look to. But what have you been doing, little fellow?"

"I've been minding sheep on the hills, sir," replied the boy.

"Yes," responded the old man, "when you should have been minding your books and gathering up knowledge to help you through the world in after life. That's not your fault though, you've to struggle for your bread, and that's dearer than knowledge, after all. It's a long time since we had a chat together, Owen—a *very* long time."

"I've been away only a little more than a month, sir," interposed the boy.

"*Only* a month," said the Captain, thoughtfully;

"but I can't remember now, at all,—my mind has quite gone. I only know I used to talk to you, and love you, boy; for many a pleasant hour I've had with you."

"Yes, sir," replied Owen, mournfully; "it was you who first taught me that the world was round, and led me to think of the stars. You told me how they all seemed to move round one fixed point in the heavens."

"Did I—did I?" mused the invalid. "Well, it's all gone out of my head—all gone—all."

"I'm sure I've often thought of you, Captain Jones," said Owen, "as I lay out on the hills at night, looking at the sky, and thanked you over and over again for all you had told me."

"Bless you, lad," murmured the old man; "bless you. You hav'n't forgotten old 'Mitter Jone,' then, as Peggy calls him."

"No, that I hav'n't, sir," responded the lad; "for when I was doing my star-papers I used to say to myself, if it hadn't been for you, I might never have thought about the heavens."

"Star-papers! What—what—what do you mean, boy?" inquired the Captain, hurriedly. "You never had any—what-d'ye-call'em?—from me, that I can recollect."

"No, Captain Jones," replied Owen, "holding the little roll he alluded to closer behind his back. "I meant the star-papers I'd been doing of late."

"You've been doing of late!" exclaimed the sailor. "Then why didn't you bring them to show me?"

Hereupon the little fellow explained to the old man that he had them with him, but that he was afraid to trouble him. The Captain, however, insisted upon seeing the boy's work, and Owen was at length forced to submit them to his view.

It was as much as the boy could do to raise the old man in his bed, and prop him up in it, with the pillows at his back. When, however, Owen found how weak and almost helpless the Captain had grown, he begged of him not to disturb himself on his account. But the kind-hearted sailor felt too great an interest in the lad to be deprived of the pleasure of seeing what he had been doing about the stars. Accordingly, as soon as his coughing fit was over, the invalid said, "Come, I'm not so bad as all that, Owen. I'm only a little bit weak; and the change of season is always so trying for me, especially the fall of the year. Ah! boy," went on the old man, "it's a sad thing to become a child again; for in your second childhood you're as helpless as you were in your first—but what's worse than all, you've just brains enough left to know how powerless you really are in the world. Little Peg is more than a match for me now, and yet I can remember the time when I've laid a hulking fellow of six foot flat on the quarter-deck for refusing to obey orders. I

wish I was like you, boy; I wish I was like you. But give me your papers."

The lad unrolled his map, and having spread it out on the bed, explained to the old man the means by which he had constructed the figures of the various constellations.

"Very well done, indeed, boy,—very well done," mumbled the invalid. "Yes; there's the Bull with the bright star Aldebaran among the Hyades; and there's Cassiopæia's Chair, and here's Orion with his belt, and the upper star in it, there, is just upon the equinoctial line. You've got the Great Dog, too, I see, with Sirius, all right; and here's the Little Dog, I declare, with Procyon in its true place —I can remember the names of them all, you see, though I almost forget my own. Ah! and there's my little favourite Pole-star, up at the top of the world. Very well done, very well done, indeed, my little man," continued the Captain, his eyes still rivetted on the chart before him. "You've got them all exactly as I've noticed them, over and over again, when I've been pacing the deck in the middle watch at night; and as I look at this bit of paper here, I can see the sky spangled over with its million lights as plainly as if they were shining above me now. I shall be among them soon—among them soon," sighed the old man, as his head fell back upon the pillow.

"You're not ill, sir?" cried Owen, in alarm.

"No, no, lad," replied the invalid, "only the sight of your chart made me think of the bright home I'm going to. It's capitally done, boy. And do you know, as I run my eye along the line of the ecliptic here, I can remember working the longitudes by many of the stars about that part of the heavens, and each one, as I look at it, calls up in my mind some long train of events."

The old man was then seized with another violent fit of coughing, which so exhausted him, that he lay for some few moments on his pillow, gasping for breath.

Then the spirit of the invalid's conversation was changed. "I wish the doctor would come," he cried, "it's his day, too, I think. Let me see, when did he say he'd come again. He was with me last Wednesday. No, no, it couldn't have been Wednesday either. What day are we at now, Owen? for I can't remember the least thing—it's all gone, boy, all gone."

Owen inquired whether the old man thought he could sleep a bit if he left him for a while, but the invalid shook his head, and he held the boy as tightly as he could by the hand. Then the little fellow leant over the pillow, and asked whether he should go over to Builth for the doctor. Whereupon the Captain opened his eyes, and smiled at Owen as he pressed the boy's hand, once more, in his.

Presently he said, "You're very good, lad—very good; but I'm better now. That dreadful cough of mine tries me sadly when it comes on. Don't leave me yet a while, Owen. I should like to have you and little Peg always with me; but you, boy, have your living to get, and she—little puss—is too full of her games for me to be able to bear with at all times."

"Shall I move these papers, sir, from the bed?" inquired the lad; "I'm afraid they're in your way."

"Wait a while, Owen," returned the old man. "I knew there was something I intended to do, and if you hadn't spoken of your star-papers just then, I should have forgotten all about it, I'm sure."

Then the Captain directed Owen to fetch the desk from below, and afterwards dictated a letter to a friend of his—a Mr. Blackwater—who, he said, was one of the most learned scientific men of the time, and had a grand observatory at the top of one of the hills on the Radnorshire side of the Wye. The old sailor, when he was Captain of the Brockelbank, had rendered this gentleman some service; he had brought him, he said, a large piece of "wootz," or Indian steel, at the time Mr. Blackwater was making some experiments on the hardening of iron, and this the philosopher had prized so highly, that he had promised the sailor to do him any favour that lay in his power. So, although the gentleman was very eccentric in his habits, and lived a per-

fectly retired life, going nowhere and seeing no one, nevertheless, the Captain said, he had little doubt that, at his request, Mr. Blackwater would allow Owen to have a peep through his large telescope, and he would be able to tell him, too, whether his star-papers were accurate or not; adding, "You'll learn more from him, boy, in an hour, if he will only talk to you, than you would get out of me in a twelvemonth."

When the letter was written, the old Captain was at a loss to remember the precise address; however, he told Owen he had only to describe the character of the person he wanted at the ferry, to be immediately set in the right direction.

At length Owen was dismissed on his errand, for the sailor was anxious to learn the result of the boy's visit; and as old Jack had been duly sent back by the young blacksmith, the little fellow was glad to avail himself of the assistance of his favourite brute to carry him on the road. So as they jogged along together, the boy chattered to the animal, now patting him for his remembrance of him on the hills, and then communicating to him, as usual, all he was about to do, and how he hoped to make Jack happy when he had grown a big man, and was able to earn a good bit of money every week; assuring him he shouldn't be left out on the common all night then, but he should have a nice warm bed

in a little stable of his own, and plenty of corn to eat, besides an apple or two, and some peppermint drops for a treat sometimes.

Owen had little difficulty in ascertaining the locality of the residence of the gentleman he was in quest of, for it was well known to every one on the Radnorshire side of the water.

The house was situate near the top of a bleak hill, and round about the grounds ran wires, that extended as far as the lad's eye could reach, while against the walls of the house itself were placed huge water barometers reaching upwards of thirty feet high. On the roof stood a curious-looking "anemometer," consisting of a large vane with a number of wheels, for measuring and registering the force and direction of the wind. On the lawn, too, were rain gauges and "drosometers," or instruments for measuring the quantity of dew fallen in the night. Here and there, against the hill-side, deep caverns had been burrowed, where the owner occasionally passed his time watching the formation of some artificial crystal in the dark. Crowning the summit of the hill a gigantic telescope might be seen, whose long iron tube looked, at a distance, more like the funnel to a steamboat than part of any optical instrument. This was pointed upwards like a huge cannon, and rested on a triangular pier of black marble that was as high as the house itself,

while over the top of the pier projected the axis on which the huge machine turned, with the end of it weighted with ponderous metal discs like iron cheeses; and down one side of the pier extended what was called the "polar axis" of the instrument, with a large wheel at the end, so that any star to which the telescope was set might be always kept in the field of view. So admirably, too, was the immense machine counterpoised, that though it weighed altogether between two and three tons, the force of a child might move it.

Nor was the interior of the building less peculiar than the exterior. The rooms were fuller of apparatus than furniture. Here stood a pair of exquisitely-delicate scales in a glass case, and there was an air-pump, with a saucer full of some curious fluid set to evaporate beneath the exhausted receiver,—and there, again, a huge glass-plate electrifying machine. Then there were "galvanometers," with their needles delicately hung under glass shades, and large gold-leaf electrometers and "eudiometers," or instruments for measuring the quantity of oxygen in the atmosphere, and "hydrometers" for telling the amount of moisture in it. There were "specific gravity" scales, too, and "acetometers," for testing the strength of acids. This room was filled with retorts and glass funnels, and graduated bell-glass receivers for gases, and gasometers, like huge japanned muff-boxes, and nests of crucibles, placed one over the other as

a Jew clothesman carries his hats on his head. Then another room was littered with "transit instruments," and "equatorials," and microscopes, and "theodolites," with large celestial and terrestrial globes, and such a medley of instruments of all shapes and contrivances, that the mind was bewildered in its endeavour to comprehend the uses of them all.

The owner of the residence was as eccentric as the house itself. It was reported that he was of noble birth, and claimed a duke for his grandfather on both sides, though he himself had never been known to allude to the circumstance. His great wealth, however, was no secret, for he had already founded a public library in the neighbouring town, and stocked it at his own expense. Thither he himself had been sometimes seen to go when in want of some book that his own shelves at home did not contain; nor did he fail, on such occasions, to sign a receipt for the volume he obtained, with as much regularity, as if he were a visitor there, either little known or little trusted.

But perhaps the most marked of his peculiarities was his aversion to strangers, for he shrank from all society, desiring ever to be alone with his books or instruments. But despite his efforts at retirement, his researches soon made him a conspicuous personage in the world of science, for he had been elected a Fellow of most of the learned Societies of London and on the continent; still such a dislike

had he for worldly honours, and so intense was his aversion to be pointed out as a great man, that he was continually striving to keep his fame a secret, and wondering why people would not leave him alone in the world.

CHAPTER XV.

THE MODERN JACOB'S LADDER.

OWEN found no little difficulty in gaining admittance to this strange individual. The boy was minutely questioned by the old man-servant at the hall-door as to the nature of his business, and was told it was no use sending the letter up, for the gentleman was too busy to be troubled, and never would allow any stranger to set foot in the place. "Scores and scores," said the servant, "used to come—and some of the first people in the country, too—but to no purpose; for Mr. Blackwater would never see any of them."

To the attendant's astonishment, however, a message was at length sent down that the boy, who had brought the letter from Captain Jones, was to be shown into the library.

Owen was not a little fluttered as he entered the room and found himself in the presence of the gentleman of whom he had lately heard so much. The

philosopher was a small, spare man, with a very large high head, that had little or no hair left upon it,—his eyes were piercing and deep set, with the eyebrows hanging half over them; his features, too, were sharp and pinched, and so austere was his look, that at the first glance he appeared to be almost deficient in human sympathy.

"So you want to have a peep through the telescope, do you?" inquired the recluse, in a shrill voice, as he looked at the little fellow through his eyebrows. "You'd much better mind your work. What do you do? Keep the crows off, eh, boy?"

"No, if you please, sir," said Owen, nervously, "I mind sheep on the hills."

"Oh! you do—do you," growled the cynic, "then why don't you keep to it instead of wasting your time star-gazing; you'll get better wages as a shepherd than you will as a philosopher. Can you read?"

The timid boy was ready to cry as he informed the gentleman that he could—a little.

"Well, then," growled on the other, "why don't you mind your books? But I dare say you fancy knowledge is to come without learning."

Owen could bear the severe manner of the man no longer, and turning his head away from him, he burst into a flood of tears.

The astronomer, on hearing the boy's sobs, was a little softened, and, rising from his seat, went

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towards him, as he said, "Come, my boy, I didn't mean to wound you. There, dry your eyes, and let me see the papers the Captain tells me you have to show me."

The little fellow handed Mr. Blackwater the chart he had brought with him, though, as he did so, he inwardly wished he could get away from the place somehow or other.

The austere man no sooner spread the map out before him, than he turned quickly round to the boy and asked, "Did you do this yourself?"

Owen nodded assent, for his heart was too full to speak.

"You didn't copy it out of any book?" inquired the other.

The boy shook his head.

"Well, then come here to me, lad," said the astronomer, in a more subdued tone. "There, don't be afraid. I seem harsh, I know, for I'm little used to deal with the world. Well, I can tell you, boy, that this map gives great promise of your doing better things some day; but only with deep study, remember, and filling your mind with the thoughts and discoveries of all the great men who have gone before you. You mustn't think, boy, that it's possible for you alone to find out all that it has taken mind after mind, from the very dawn of knowledge, to heap together; for every science, remember, is built up by a number of workers, each adding only the

smallest fragment to the general structure, like the tiny creatures whose united labours form, in the course of ages, immense reefs of coral."

The philosopher then led Owen to a large planisphere of the heavens that hung against one side of the library, and he there pointed out to the boy the defects of his little chart; showing him how he had crowded under the same horizon, at the same time, stars that could have become visible only at different periods. And as he compared the figures of the different constellations with those delineated by the shepherd-boy, he pointed out to him the various double stars that had been discovered, and told him how these had been found to be revolving round each other, like a twin sun; and how some again formed a threefold arrangement, each continually circulating about the others—"as if," said Mr. Blackwater, smiling grimly, "they were dancing a reel." Then he pointed out to the boy the different fixed stars, of which the parallax had already been ascertained; and told him how, though the sun was, in round numbers, 100 millions of miles distant from the earth, the Pole-star was upwards of 3 million of times farther removed from us than the sun was, or more than 300 billions of miles altogether; which, he added, was such a distance, that the light from it, though travelling more than 11½ million miles a minute, would take no less than 50 years to reach our eyes; so that though we

fancy we see it of a night in the place it occupies, at the moment of our looking upon it, we really and truly behold it in the position it was in half a century before."

Owen, who had grown more at ease as the philosopher became more kindly and communicative, was about to ask the gentleman for an explanation, as to how he could possibly see the Pole-star where it was 50 years back; but Mr. Blackwater proceeded to tell him that it was from the discovery of the "parallax" of some of the fixed stars that they had been able to infer the distance of the others, according to their several magnitudes. "Those of the first magnitude," he went on, "are the brightest that we see, and are upwards of $1\frac{1}{4}$ million times farther removed from the earth than the sun is. Those of the second magnitude are more than 2 million times the distance of the sun from us, and those of the third magnitude more than 3 million times as far from the earth as the sun, and so on down to the sixth magnitude, which are the smallest stars that are visible to the naked eye. The latter are, in round numbers, $8\frac{3}{4}$ million of times farther than the sun from the earth, or," said he, "the light that you see them by at night is that which left them more than 130 years ago, while it has been calculated that the stars of the ninth magnitude—which the telescope alone renders visible to us—are sunk so inconceivably distant in the great ocean of space, that a flash of

light, leaving them at one moment, would take nearly 600 years to traverse the immense gulf that lies between us and them."

All this was so overpowering to the boy, that he could not refrain from inquiring how it was possible for men to know as much.

The Astronomer asked the lad if he knew how the distance of the nearest of the heavenly bodies was arrived at.

The little fellow told Mr. Blackwater that he had long wanted to understand it; adding, that he had often, as he lay out on the hills, wondered how it was possible to measure the distance of things that there was no getting near to.

The philosopher smiled at the doubt of the boy, and said, "Well, I'll try to give you a notion as to how it is done. Do you know what parallax means?" inquired the philosopher.

"Captain Jones, sir," answered the boy, "told me that parallax was the different place that an object appeared in when we looked at it from a different point of view."

"I am glad to find you know so much already," answered the Astronomer. "Parallax is simply that *apparent* change of place in an object which arises from a *real* change of place of the observer."

"Yes, sir," said Owen, encouraged by the approbation of one who seemed so difficult to please. "I know that if you hold a coin close before you, and

look at it first with one eye and then the other, it appears to shift its place, because we are then viewing it from different points."

"There's a brave lad," added Mr. Blackwater, not a little astonished to find the boy had so thorough a knowledge of the matter. "Well, then, listen! The coin held close before us, and viewed with each of the eyes successively, is only a simple illustration of one of the highest astronomical principles—the one, indeed, by which the distance of the sun and planets is arrived at, and even that of the fixed stars measured; for we have only to imagine each of our eyes to be a different observer situate at different parts of the earth, or of the earth's course round the sun;—that is to say, we have but to fancy the $2\frac{1}{2}$ inches that our eyes are apart to be expanded into 4 thousand miles, the semi-diameter of the earth,—or into 95 million miles, the semi-diameter of the earth's orbit, and to regard the coin as some immense orb millions of miles removed from us—to have a perfect notion of what is meant by the parallax of the sun and stars."

"I hope you wont be angry with me, sir, for saying I cannot make out how you can measure the distance of a thing in that way?" said the lad, timidly.

"No, no, boy!" went on the Astronomer. "Anything I can tell you, I will. Well, my lad, if you notice what takes place with an object held close before you, you will find that the nearer it is to

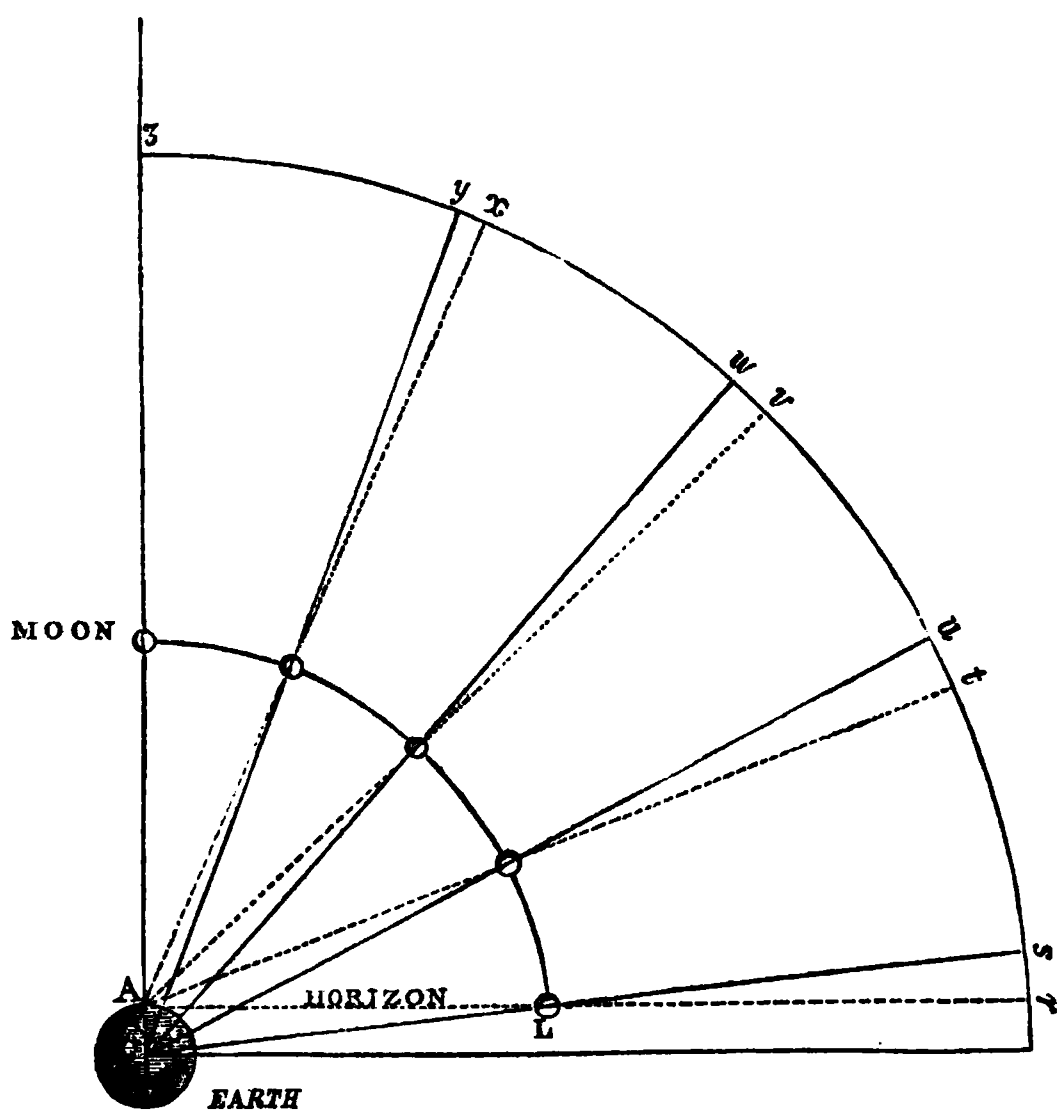
you, the greater the space it appears to travel through as you regard it first with one eye and then the other. There, hold your finger up and see whether I am right."

"Oh, yes! sir," cried Owen, as he made the simple experiment; "when my finger is close in front of me, it seems, as I open one eye and shut the other, to move half across the book-case yonder; but when I hold my finger as far away from me as I can, it moves only the length of a few books."

"So then," was the reply, "you perceive that the *nearer* an object is to you the *greater* is its apparent change of place, when viewed from different points of sight, and on the contrary, the *farther* an object is off, the *less* is its apparent change of place when regarded from different situations. Now let us see if we can measure the distance of the moon from the earth by such means. Well then, lad, if the earth were perfectly transparent, it is evident that a person at the centre of it would see all the celestial bodies in their true places in the heavens; for the centre being a fixed point, he would continually remain in the same position; consequently as the parallax of objects, or their apparent change of place, proceeds only from a real change of place in the observer; and as a person situate at the centre of the earth would never alter his position, the sun, moon, and stars could have no parallax to him. Do you follow that?"

"Yes, sir," replied the boy; "but I should never have thought of such a thing, I am sure."

"No, of course you wouldn't," continued the Astronomer, "nor a hundred others older and wiser than you. Well, let us suppose one person to be situate on the surface and the other at the centre of the earth, and see how the moon would appear to two such observers. But I can show you a drawing of that already done;" and, so saying, Mr. Blackwater drew a volume from the bookcase, and, spreading it out before the boy, exposed the following engraving to his view.



"Now the larger sphere you see here represents the earth, and the smaller one the moon; and supposing a person to be stationed at the top of the globe here, and another to be at its centre, it is plain that when the moon was in the zenith, or exactly over the heads of the two as at *z*, they would both see it in the same place; whereas when it had appeared to pass from that point a little way towards the horizon, the observer at the surface would, in the course of the revolution of the earth, have shifted his place with regard to it, and consequently, see it in the direction of the dotted line at *x*; while to the person at the centre, who would have *remained in the same place all the time*, it would appear in the direction of the other line at *y*; that is to say, the moon would be seen from the *middle* of the earth in its true position, whereas, at the *surface*, it would appear depressed towards the horizon, and be referred to a point in the heavens that was some little distance removed from the real place it then occupied. Then, as the moon seemed to draw nearer the horizon, it would be more and more displaced, and when it reached the horizon itself, the extent of the displacement would be the greatest of all, for the observer at the centre would see it in the direction of the line at *s*, while, viewed from the surface, it would then appear considerably below its true place in the heavens, or in the direction of the line at *r*. This constitutes what is called

the 'horizontal' parallax, which signifies simply the difference in the apparent position of any celestial body at the horizon when viewed from a station on the *surface* of the earth and from the *centre*. Now, to comprehend this, you have only to fancy, as I said before, the distance between your two eyes to be equal to the semi-diameter of the earth, and to imagine the moon to be like the coin held in front of them, and then you will perceive how the one eye at the surface would see the object in a different position from the eye at the centre.

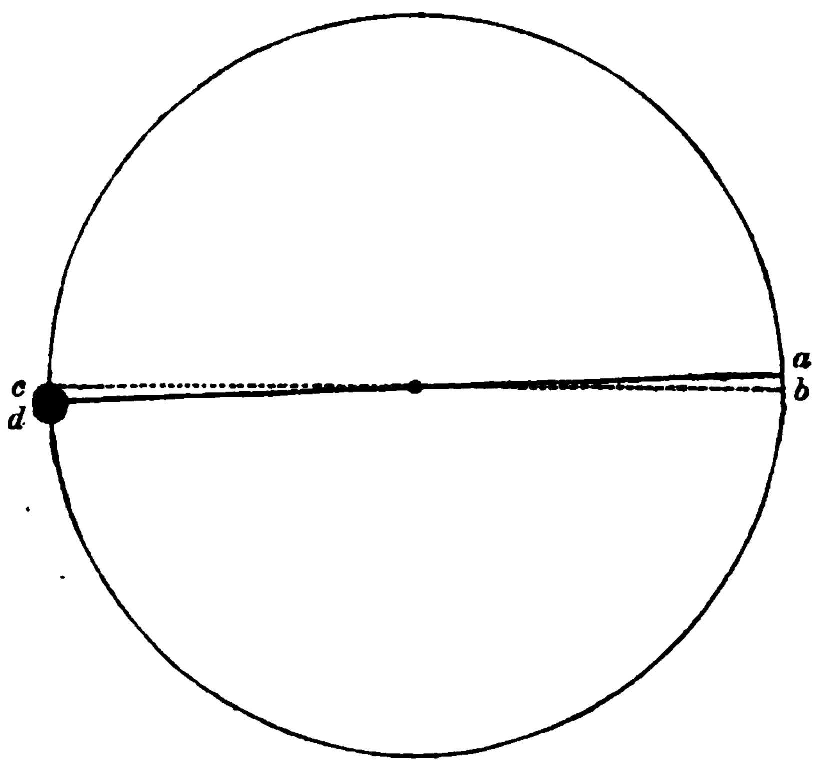
Owen assured the Astronomer that he could follow this part of the subject with little or no difficulty, but still he could not make out how it was possible to tell the distance of the heavenly bodies in such a manner, since no one could get to the middle of the earth to see them in their true positions.

"Well," proceeded Mr. Blackwater, "there are other ways of finding that out than by observing the sun and moon from the centre of our globe. For instance, the moon appears to revolve about the earth from the meridian back to the meridian again in about 24 hours 48 minutes, consequently she should go a fourth part round it in a fourth part of that time, or in 6 hours and 12 minutes;—that is to say, if we could get to the middle of the earth, we know this would be the time that the moon would be found to occupy in performing

exactly one quarter of her apparent daily revolution about our globe. But as observed from the earth's surface, she seems to go from the meridian to the horizon in a *little less* than a fourth part of the 24 hours 48 minutes; and if you were to take note of the exact period, you would discover that instead of taking 6 hours and 12 minutes to do that much of her journey, she would seem to you to perform it in about 3 minutes less. Now this affords us an easy method of ascertaining the extent of the angle formed by the moon's horizontal parallax, for we have but to convert the number of minutes that her journey from the meridian to the horizon was short of the 6 hours 12 minutes into parts of a degree, in order to find the precise extent of her parallax at this point of view. By such means as these, then, we learn that the moon's horizontal parallax is 57′ 18″ or some few minutes less than 1 degree.

Now if you look at the engraving, you will perceive that what we call the moon's horizontal parallax represents the angle under which the semi-diameter of the earth would appear to an observer in the moon; that is to say, the line A C would, at the moon, be seen under an angle of 57′ 18″, or let us call it, to simplify the matter, 1 degree. Now we know that this measures just upon 4000 miles, so we have only to complete the circle of which this 1 degree is a part, in order to find out the exact dimensions of the whole. Well, there are, you know,

360 degrees to every circle, and as one of them measures 4000 miles, the whole 360 must of course measure 1,440,000 miles, and this gives us the entire extent of the circumference of the circle of which the moon is the centre. Then, dividing that amount by 3, we have 480,000 miles for a rough approximation to the length of its diameter, and halving that again, we get 240,000 miles for the semi-diameter or distance that the moon is from the earth. However, let us make a drawing of this, and you will see it in an instant.



There, boy, the little dot in the centre of the circle," proceeded the philosopher, "represents the moon, and the small circle at the edge of the larger one, the earth. Well, an eye at the *centre* of the earth would see the moon in its *true* position in the heavens in the direction of the thick line, and refer

it to a point at (*a*), whereas an eye at the *surface* would see that celestial body in the direction of the dotted line referring it to a place in the heavens at (*b*); this, then, you see, would constitute the moon's horizontal parallax. Now this parallax we know by measurement to amount to a little less than 1 degree, and as when two right lines cross each other the opposite angles are equal, we know also that the arc, or portion of the circle included between the lines *c* & *d* must be exactly equal to the arc or portion of the circle on the opposite side included between the lines *a* & *b*. But we know, moreover, that this portion of the circle is equal to the semi-diameter of the earth, and consequently is in round numbers 4000 miles long.* Then, as the space between *c* & *d* represents 1 degree, and this is the 360th part of the entire circle, it is plain that the length of the whole circumference must be 360 times 4000 miles. Therefore, knowing how many miles it is round the circle, we can easily find how many miles it is across; and then halving that quantity, we shall arrive at the exact distance from the circumference to the centre, and so learn how far the moon is removed from the earth."

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* The line formed by the semi-diameter of the earth would be what is called the "tangent" of this arc. In small angles, however, the length of the arc is very nearly the same as that of its tangent.

"I'm sure I thank you, sir," cried the boy, delighted to find that he could now follow the explanation. "I never thought I should be able to understand it, but now I can see how the distances of the moon and stars are measured, and before, sir, I used to think it was all guess work, and that it was impossible for any one to tell exactly how far they were off. Can you find out how far the sun is from the earth in the same manner, sir?"

"Yes, partly so, boy," replied the astronomer; "and the parallax of the sun, owing to its being much farther removed from us than the moon, is found to be not quite 9 seconds of a degree.* Now, to ascertain how far a body, having such a parallax, is removed from the earth, we must go through the same reasoning as we did in the case of the moon, bearing in mind, however, that the arc, or portion of the circle included between the lines *c d*,† represents in the case of the sun not quite 9 seconds of a degree; consequently, as there are 1,296,000 seconds altogether in 360 degrees, that arc will be only the 144 thousandth part of the entire circumference; hence, as the 144 thousandth part of the circumfe-

* The sun's parallax is only 8″·6, instead of 9″, as has been assumed for the sake of simplifying the calculation; consequently, the sun's distance from the earth is less than abovementioned, being generally taken at 95 million miles instead of 96.

† See Engraving, p. 433.

rence measures 4000 miles, the entire circle having the sun for its centre, must measure no less than 576 million miles round. Then dividing this by 3, we have 192 million miles for the length across the circle, and halving that, gives us 96 million miles for the length of its semi-diameter, which is about the distance of the sun from the earth."

"And is that the way, sir," inquired Owen, "the distances of the planets and fixed stars are got at?"

"Yes, boy," answered Mr. Blackwater, "it is by some such means, though there are other ways of doing the same thing, but I needn't trouble you with them just now. I should tell you, however, that on account of the difficulty of making accurate observations at the horizon, owing to the refraction there, the parallaxes are usually determined by observations made by persons, stationed for the purpose, at different parts of the earth; for instance, one we will say is located at Vienna, and another at the Cape of Good Hope—which two places are on the same meridian, but in different hemispheres, and very nearly 83° latitude removed from each other. Thus the two eyes are nearly one-fourth of the circumference of the earth apart, and the same celestial body being observed by them is seen by each out of its true position. Accordingly, on an appointed day, two observers measure how many degrees the object, whose parallax they wish to obtain, appears to be distant from their respective

zeniths at the moment of its crossing the meridian. Then adding these zenith distances together, they find that the sum of them amounts to more than the sum of their latitudes, and the excess is the extent of the angle that the object has been displaced in the heavens, whence the horizontal parallax is easily calculated."

"But I hope you wont think me troublesome, sir," said the boy, timidly, "if I ask you how you tell the sizes of the sun and moon?"

"No, boy," smiled Mr. Blackwater; "as we have some little time to wait before you can have a peep through the telescope, we may as well occupy ourselves that way. When we know the distance of a body and the angle under which it is seen, it is not very difficult to calculate its size, for the angles under which we see things become greater or less according as the objects are larger or smaller, or farther or nearer. For instance, an object close to the eye is seen under a much larger angle than one a long way off, and that is the reason why a man on the top of a lofty building appears no bigger than a child. The fact is, he is seen under a smaller angle, and therefore *appears* smaller."

"But I can't make out, sir," interposed the lad, "what you mean by seeing things under an angle."

"Well, look here, boy," continued the astronomer; "as I stand before you, if you were to draw a thread from my feet and my head so that the ends

met at the pupil of your eye, those two threads would represent the angle under which you are viewing me; for you see all things merely by luminous threads, or rays of light as they are termed, sent from the objects to your eye. But if you were looking at a smaller object at the same distance off from you as I am—as for instance at this book which I hold now in my hand—and a thread was to be drawn from the top and bottom of it to your pupil, then of course the threads from the book would not be so wide apart on coming to your eye, as the threads from me would be; so that the book being smaller, you would see it under a smaller angle. But now suppose I was to leave the book where it is, and with the threads still fastened to my feet and head, I was to go farther away, you would find that as I retired, the threads instead of being wide apart as they approached your eye, like they were at first when I stood near you, would, the farther I went, come closer and closer together, and so form a smaller angle, until at last, when I had retired to some considerable distance, they would be in a line with the threads from the book, and then you would see me under the same angle as the book itself."

"Ah! now, sir, I understand what you mean; thank you," said Owen.

"Well," continued Mr. Blackwater, "if you look again at the diagram I have before shown you concerning the parallax of a body, you will see that the

parallactic angle is merely the angle under which a person in the moon or sun would see the semi-diameter of the earth; for you have only to suppose an eye to be placed at the point where the lines drawn from the centre and surface of the earth meet, and to imagine those lines to represent two rays of light, in order to comprehend that such must be the angle under which that portion of the earth would be seen. Now this angle we know by measurement to be, in the case of the moon, 57′ 18″, and then doubling this we have 1° 54′ 36″, or 6876″ altogether, for the angle that the entire diameter of the earth would be seen under at the moon. Moreover, we know by measurement that the diameter of the moon is seen by us under an angle of 31′ 2″, or 1862″ altogether. But I have shown you that the sizes of bodies at the same distance from the eye are in proportion to the angles under which they are viewed; for you remember I pointed out to you that you saw me under a greater angle than you beheld the book when we were both at the same distance from you. Accordingly, as the distance between the moon and the earth must be the same, whether we suppose an observer in the moon to be viewing the diameter of the earth, or an observer on the earth to be viewing the diameter of the moon, it follows that the *real* diameters of these bodies must be in the same proportion as their *apparent* ones, and as these are respectively 6876″ and 1862″, therefore the *real* dia

meters must be as 369 to 100, that is to say, the diameter of the earth must be very nearly $3\frac{7}{10}$ greater than that of the moon. Then, as we know the earth to be in round numbers 8000 miles across, we thus find that the length of the moon across must be 2180 miles."

"So then, sir," remarked Owen, thoughtfully, "the moon is about a quarter as big as the earth? More than two thousand miles across! And yet it doesn't look any larger up there than father's grindstone; does it, sir? How big is the sun, if you please, sir?"

"Why," continued Mr. Blackwater, "the sun is so large that it would require about 880 earths put in a line, one after the other, like so many cannon balls, to reach across that body; or if the sun were placed close against our globe, only about one-quarter of his diameter would fill up the space between us and the moon, which you remember is 240 thousand miles away from us."

"Oh! dear!" exclaimed the lad, lost in wonder, "to think the sun would reach up to the moon!"

"Yes, boy," added the astronomer, "and three times farther, too. But now let us see how this is made out. The entire diameter of the earth, viewed from the sun, would, of course, be seen under double the angle that the semi-diameter of it would; and as the angle that the semi-diameter of the earth is seen under from the sun is the same as the sun's

parallax, which you know I told you was not quite $9''$ of a degree, it follows that the entire diameter of the earth would, if observed from the sun, be seen under an angle of $17\frac{2}{10}''$. But the sun's diameter, as seen from the earth, measures a little more than the moon's, or $32'$ $3''$, which is $1293''$ altogether. Consequently, the *apparent* diameter of the earth, seen from the sun, being $17\frac{2}{10}''$, and the *apparent* diameter of the sun seen from the earth being $1923''$, the *real* diameters of those bodies must be in the same proportion, or very nearly as 1 to 111; that is to say, the sun must be about 111 times bigger than the earth itself, so that the earth being 8000 miles across, the length across the sun must be something like 888 thousand miles, which is nearly four times greater than the distance of the moon from us."

CHAPTER XVI.

"STAR-DUST."

"I AM sure I have to thank you much, sir, for explaining all this to me," said the grateful little fellow. "But the planets, sir? are they nearer to the earth than the fixed stars?"

"Yes, my boy, they form part of what is called the solar system," responded the astronomer; "that is to say, they all revolve round the sun as their centre, just as the earth itself does, and, consequently, they appear to be continually shifting their places among the stars, which, on the other hand, always seem to occupy the same positions among one another in the heavens. Now, what is called the solar system consists of no less than 50 celestial bodies, of which the sun is the principal or centre, so that, regarded as a part of the stellar universe, it is merely a cluster of stars linked together—the earth itself forming one, and by no means the largest of the number."

"Do we live then upon a star, sir?" inquired the astonished boy.

"Yes, lad; and a very small star, too," answered Mr. Blackwater; "for Sirius, which is the principal star in the constellation of the Great Dog, has been calculated to be considerably larger than our sun, so that to an observer in the Dog-star, the sun itself would dwindle down to a mere bright point, and the earth be invisible even with the highest magnifying power. Well, boy, there are 30 primary orbs in our system revolving about the sun as *planets*, and 20 secondary orbs revolving about these primary ones as *satellites or moons*. So that comprising the sun, our system numbers, as I said, no less than 50 bodies. The little cluster of stars, of which we form a part, consists of a disc of space 600 million miles across, with the sun in the centre, and 30 primary orbs, as they are called, circulating at different distances about him. You have, I dare say, noticed the circles formed on a pool when a stone has been thrown into it. Well, imagine that pool to be a vast aerial ocean, and the circles upon it to be immensely larger, so that every inch is expanded into a million miles, and then those circles will give you a rough notion of the orbits of the planets in our system. Now there are 30 such planets, remember, continually circulating about the sun, 22 of these being mere fragments of worlds, or '*asteroids*,' as they are called, and the other 8 im-

mense bodies travelling quicker and quicker the nearer they are to the great central orb ; for *Mercury*, which is the nearest of all, is carried along at the rate of 170 thousand miles an hour, *Venus* at 80 thousand miles, the *Earth* at 68 thousand, and so on, the speed becoming less and less till we reach *Uranus*, whose rate of motion in its orbit is only 15 thousand miles in the same time.* Consequently *Mercury* travels as much quicker than *Uranus* round its orbit as a railway train goes faster than a man walking. Then, again, about some of these primary orbs themselves there are 20 other secondary orbs or moons always revolving, the *Earth* having 1 such attendant, *Jupiter* 4, *Saturn* 7, *Uranus*, it is believed, 6, while

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* Kepler, the celebrated astronomer of Wirtemberg, was the first to point out that the squares of the times in which the planets revolve about the sun, are in the same proportion as the cubes of their distances. For instance, the periods in which the Earth and Mars complete their revolutions in their orbits are respectively $365\frac{2564}{10000}$ days, and $686\frac{9796}{10000}$ days, which are in the proportion of 100,000 to 188,081, while their distances from the sun are in round numbers 95,000,000 miles and 144,000,000 miles, or more accurately, in the proportion of 100,000 to 152,369. Now, it will be found on making the calculation, that 100,000 (multiplied by itself) is to 188,081 (multiplied by itself) as 100,000 (multiplied by itself twice over) is to 152,369 (multiplied by itself twice over). That is to say, the squares of the times in which the planets revolve about the sun have the same proportion to each other as the cubes of their distances from that body, so that knowing the time in which any planet completes its orbit, we can thus arrive at its distance, or *vice versâ*, knowing its distance, we can deduce its time.

Neptune, so far as our knowledge at present leads us to surmise, has only 2."

"You give me thoughts I never had before, sir," said the boy; "and I wish I had nothing else to do but to study these things, though the numbers of miles you speak of are so large that they quite confuse me."

"I dare say they do, my lad," returned the astronomer, in a kindly tone. "But let me see if I cannot give you a better notion of the solar system, and the comparative sizes and distances of the planets by some familiar illustration. Well, then," continued Mr. Blackwater, "we will suppose ourselves to be in the middle of a large level plain three miles across. Now, if in the centre of this we were to place a very big pumpkin, two feet in diameter, that would represent the *Sun;* and then, if at the distance of rather more than 50 yards, which is about the length of the aisle of a large church, we were to place a little ball scarcely bigger than a silk-worm's egg, that would give you an idea of the size of *Mercury* in comparison with that of the sun; while a white currant placed at not quite a hundred yards from the centre would stand for *Venus;* and another currant at the distance of nearly 150 yards, which is about the length of the aisle of a large cathedral, would be a type of our *Earth*. *Mars* might be shown by a coral bead no bigger than a small shot, placed rather more than 200 yards from the centre, and that

is about the width of the base of the *largest* of the Egyptian pyramids; and the group of *asteroids* or little planets by grains of sand placed at 300 or 400 yards — which is rather less than a quarter of a mile—from our model sun. *Jupiter*, on the other hand, would be a good-sized orange at nearly half a mile, and *Saturn* a little orange at about $\frac{4}{5}$ of a mile from the central orb, while *Uranus* would be exemplified by a crab-apple at the distance of $1\frac{1}{2}$ mile from the centre, and that is about as far as a balloon ordinarily rises in the atmosphere."

"Oh! thank you, sir," exclaimed Owen. "I see it much plainer now. But how big Jupiter *must* be to be like an orange, while Mercury is only the size of a silkworm's egg compared with him. But is this cluster of stars you speak of, sir, and which you say occupies a space in the heavens 600 million miles across, a mere speck, after all, in the universe?"

"Yes, lad," responded the astronomer, "it most assuredly is, for some of the fixed stars are so far distant from us, that, as I said before, their light, though travelling more than 190,000 miles a second, would take centuries to reach our eye; for the beams we see them by, as they appear twinkling above us in the night, are those which left them hundreds of years ago."

"Oh! that reminds me, sir," suddenly cried the boy, as the thought struck him, "that I wanted to

ask you, if you please, how it was you could tell that the little Pole-star is so many millions and millions of miles away from us that we see it every night in the place where it was fifty years back? That seemed to me more wonderful than anything you have told me yet, and so astonishing that I could hardly believe it was possible for people to be able to find out such things."

"I dare say, my little man," added Mr. Blackwater; "but it *is* possible now to speak with accuracy on such matters, and the means by which the knowledge is attained is one of the greatest discoveries of modern times; and perhaps of any time whatever. It is arrived at, however, simply by finding the parallax of the fixed stars, though by a somewhat different method from that by which I explained to you the parallax of the sun and moon was found. You remember I showed you that we ascertained the distances of the last-mentioned bodies merely by learning how many degrees, or parts of a degree, the semi-diameter of the earth would appear to be extended over, when seen from them; that is to say, we used the diameter of our own immense globe as a yard-stick wherewith to tell the length of the spaces between us and the sun and moon. But though this measure is no less than 8000 miles long, it serves us only as a guide for those orbs which are comparatively near us; but as all things become less and less the farther

they are removed from the point of sight, the semi-diameter of the earth dwindles to a mere molecule, smaller than the motes in a sunbeam when regarded from a distance like that of the fixed stars. Accordingly we have to seek for some longer tape by which to measure these bodies — some standard of length so much greater than the other, that when viewed from the remoteness of the fixed stars themselves, would appear to extend itself over some *small space at least* in the heavens. Such a standard then we obtain in the diameter of the earth's orbit, which is in round numbers no less than 190 million miles across. But even this length, prodigious as it seems to use as a foot-rule, being nearly 24,000 times greater than the diameter of the earth itself, shrinks into the dimensions of a grain of seed when applied to the fixed stars—at such stupendous depth do those orbs lie in the great celestial ocean which encompasses us! For so minute does even this immense measure become, when regarded from the depths of space, that instead of reckoning by minutes and seconds, as we did with the diameter of the earth when applied to the sun and moon, we come to tell our distances from the fixed stars by *thousandth* parts of a second, even though the standard we are applying to them is the diameter of the earth's vast orbit itself."

"What a way off they must be!" mused the lad in his wonderment.

"Well, you recollect," continued the philosopher, "how we found the parallax of the sun and moon by expanding the distance between the eyes into that of the semi-diameter of the earth. We supposed, you know, one eye to be at the centre of our globe, and one at the surface, and in that manner we ascertained how far those bodies would appear to be diverted from their true positions in the heavens; while the reason for our placing an eye at the centre was that it was a fixed point, and accordingly an observer there never shifting his position during the rotation of the earth, would see the celestial bodies in their true places. But when we deal with the earth's orbit, instead of its mere diameter, we have to imagine an eye to be placed at the sun itself, since that is the centre or fixed point of the circle that our globe describes annually in the heavens; an observer there would, consequently, see the stars always in their true positions, while we, regarding them from one side of such circle, must see them more or less displaced. If you refer once more to the diagram illustrating the sun and moon's parallax you will at once understand this part of the subject;* for you have only to fancy that the circle which we before used to represent the earth itself to be the earth's orbit, and the point C in the centre to stand now for the sun, while the smaller circle L,

* See Engraving, p. 429.

which was previously intended for the moon, is the fixed star whose parallax we are seeking to measure. Then as the eye at the sun in the centre C would see that star in its true place, and the eye at the side of the orbit, as at A, out of its true place, it is plain that we have only to measure how many parts of a degree the star appears to us to be displaced in order to ascertain its parallax—which, for the reason I have before given you, would be the measure of the semi-diameter of the earth's orbit. That is to say, we should ascertain by such means how many parts of a degree, the length of our distance from the sun, if viewed from that fixed star, would appear to occupy in space. Now the parallax of the Pole-star, arrived at by a modification of such means as these, is found to be only 67 thousandth parts of a second of a degree. Then portioning the entire circle out into thousandth parts of a second, we have 1296 million such parts; and dividing this by 67 (the extent that the semi-diameter of the earth's orbit would appear to occupy if viewed from the Pole-star) we find that the circumference of the circle of which the Pole-star is the centre, must be in round numbers 19½ million times longer than the semi-diameter of the earth's orbit. Then dividing this by 3, and halving the quotient, we obtain the semi-diameter of this immense circle, and so learn that the Pole-star is no less than 3¼ million times our distance from the sun. This reduced into miles gives us the overwhelming

amount of 312 billions for the length of space between us and the little star which we see twinkling of a night at the pole of the world."

"Oh! goodness!" cried the little fellow, "and I've looked at that beautiful little speck of light over and over again, and thought it but scarcely farther from me than some of the jack-o'-lanterns I have seen floating a long way off in the air over the marshes."

"But the parallax, boy, of only a few fixed stars has as yet been measured," went on Mr. Blackwater; "those, however, which have been already ascertained, are sufficient to make us marvel at the vastness of space, and the inconceivable distances of bodies that we are in the habit of gazing at every night. When we look at that beautiful large brilliant white star called *Vega*, at the corner of the constellation of 'the Lyre,' what person—unless conversant with the reasoning upon which the knowledge depends—would believe that it was more than a million times farther from us than we are removed from the centre of our system? Or who, gazing at *Arcturus*—which is the large star that the eye rests upon when glancing straight from those in the tail of 'the Great Bear'—would think it possible that the interval between us and it could measure more than 1½ million times our own distance from the sun? Or, again, that the light which sparkles from the star in the beak of 'the Swan' would take

10 years to reach the eye; and that the beams from the star in one of the paws of 'the Great Bear' would be no less than 25 years travelling to our globe, even though the velocity of a ray of light is such that it darts through 192,000 miles in one swing of the pendulum?"

"But, sir," cried Owen, "I cannot make out how you can tell that light travels at such a rate?"

"That is easily explained," replied the philosopher, "and the discovery was made nearly 200 years ago, by a Danish astronomer named ROEMER. You remember I told you that *Jupiter* had 4 moons, and these as they revolve round the orb are continually being eclipsed by it. Well, the Dane perceived, on comparing the recorded times of the eclipses of these moons during many years, that when the earth, in the course of its revolution in its orbit, came nearly between the sun and Jupiter, and so was nearest to the planet, the eclipses took place some few minutes *too soon;* that is to say, they occurred earlier than they should, according to the calculation of the periods of the revolutions of those satellites; whereas the eclipses which happened when the earth was farthest from the planet, were always some few minutes *later* than they should have been. Accordingly, the Danish astronomer concluded that to bring the calculations as to the regular periods for the return of these eclipses into accordance with the observed facts, an

allowance in time must be made of nearly 16½ minutes, for when the earth was in that part of its orbit which was *nearest* to Jupiter, the eclipses happened just upon 8¼ minutes *before* their regular time; and when the earth was at that part of its orbit that was *farthest* from the planet, they occurred about 8¼ minutes *after* their regular time. Speculating, then, on the probable cause of this phenomenon, he could see no other mode of accounting for the fact than the supposition that light, instead of passing *instantaneously* through space, required *a certain time* to dart from one point of the universe to another. So as it took 16½ minutes to pass across the orbit of the earth—and that you know is 190 million of miles in length—why it must travel at the rate of 192,000 miles a second; a velocity so great that it startled many when the matter was first propounded, and made them hesitate to receive the explanation as truth until it had obtained some confirmation. Such confirmation, however, has been afforded it—and that of the most indisputable kind—in the after discovery of the principle of "aberration." Accordingly we now know that a ray in leaving a particular star must occupy a certain time in travelling through the space between the earth and it, and though the velocity of light is such as to be almost inconceivable, still we have measured the rate of motion, among other principles as subtle as light itself, and found that electricity travels

along a wire with a speed that *exceeds* that of light through planetary space: this, too, remember, is the power we now use to transmit our messages from one part of the earth to the other, with even a greater rapidity than the beams of the little Pole-star come twinkling to our eyes of a night, revealing it to us *where it was some half century ago*. But here is a drawing that will make the eclipses of Jupiter's satellites, and the facts upon which the velocity of light depends, still more plain to you." Whereupon the astronomer taking another volume from the book-shelves, set the following illustration before the boy.

"Oh! that's the *Sun* in the middle, I suppose, sir?" remarked the lad, as he eyed the picture up and down; "and the balls round the circle about the Sun, stand for the *Earth* in different parts of its orbit; don't they, if you please, sir?"

"Yes, you're quite right," returned Mr. Blackwater; "and as the earth makes the tour of its orbit in twelve months, the balls, as you call them, represent the positions that our globe would occupy every two months throughout the year. Now, the straight lines which divide the circle into six triangles are all of the same length, for those triangles are what are termed equilateral, or equal-sided ones. Consequently, the lines connecting the six different points round the circle are exactly equal to the lines drawn from the circumference to the centre. So that when our globe in the course of its revolution in its orbit has passed from any one of those points to another, it will have moved through a part of space which, if measured in a straight line, would be exactly equal to its distance from the sun. The figure at the top of the drawing represents the planet *Jupiter*, with its nearer side illumined by the rays of the sun, while the farther one is in darkness, and projects a shadow behind it, just as a house does with the sun shining upon it; and those little dots placed round the four circles that encompass the planet, are intended for the four moons circulating about it. One of these you per-

ceive—that which is the nearest of all to *Jupiter*—is about to enter the shadow, and so to be eclipsed by it, or, what is the same thing, obscured from our sight. This moon is about 350 miles greater in diameter than our own, and about 20,000 miles nearer to Jupiter, while it revolves round the planet in little more than $1\frac{3}{4}$ days. Accordingly, since it completes its revolution about the orb in just upon $42\frac{1}{2}$ hours, it is evident that interval of time should elapse between the moments of its entering or quitting the shadow of the planet in the course of any two successive revolutions. But it is found, as the earth passes from the point of its orbit that is *farthest* from *Jupiter* (see *fig.* 6 in engraving,) to the point which is *nearest* to it, (see *fig.* 3), the satellite appears to enter the shadow some few minutes *sooner* than it should, according to the rate of its revolution; while as the earth passes from the point of its orbit *nearest* to *Jupiter* to that farthest from it, the satellite, on the other hand, appears to quit the shadow some few minutes *later* than it ought. For instance, suppose the earth to be at the point of its orbit marked 1 on the 1st of June, and the precise period of the satellite's entering the shadow of the planet to be noted; it would then be found, on the earth's reaching the 2nd point, two months afterwards, on the 1st of August, that the immersion of the satellite into *Jupiter's* shadow would occur $8\frac{1}{4}$ minutes *earlier*

than it did on the 1st of June. Whereas, when the earth reached the 5th point in its orbit—and it would do this about the 1st of February—the satellite would be seen to emerge from the planet's shadow 8¼ minutes *later* than it did when the earth was at the 4th point, two months before. Now, boy, as the straight lines connecting these several points are exactly equal to the earth's distance from the sun, it is plain—since the light, or first gleam, caught from the satellite after its quitting the planet's shadow took 8¼ minutes longer to reach the eye at the 5th point of the earth's orbit than it did at the 4th, and the distance between those places measured in a straight line amounts to 95 million miles—it is plain, I say, that the light must have travelled through that space at the rate of 192,000 miles a second.

"There now, boy," added Mr. Blackwater, "I've told you how to measure the distance, and to reckon the sizes of the sun, moon, and planets—and I have told you, moreover, how the lengths of the infinitely greater spaces between us and the fixed stars are arrived at, explaining to you how some of the little points of light with which the sky sparkles at night-time, are so far removed from us that the mind is unable to conceive their distances as reckoned in miles, and therefore they are usually expressed in the number of years that their rays occupy in coming from them to us—even though light itself travels so

swiftly that it would flash through the long interval that separates the moon from us, in but little more time than is occupied by one tick of the clock."

Owen once more expressed his gratitude to the astronomer for the many wonderful things he had explained to him; and as he grew to know him better, he got to speak to him more frankly; while the philosopher's aversion to a stranger, which had become less and less as he found the uneducated boy evince so lively an interest in the subjects with which he himself was deeply engrossed, had given place almost to a liking for the lad. Consequently, when the discourse about the stars was finished, Mr. Blackwater began to question Owen as to how he had learnt all he knew, and listened with no little delight as the boy ran over to him all the experiments he had made about the lever, and how he had contrived his humble apparatus of beads for ascertaining the figures of the contellations. Nor did the little fellow forget to tell Mr. Blackwater about the clock he had constructed, and the difficulty he had in finding a substitute for a bell, and how at last he had made his timepiece strike the hours on the neck of a broken bottle. The boy, too, told all these things so simply and modestly, that though the philosopher was little given to sympathy, he could not help feeling, when he heard them, that it was a pity so ingenious and thoughtful a lad should be destined to a life of manual labour. The As-

tronomer, however, assured the boy that any books he wanted to read he should have from his public library, provided he would take great care of them; and he wrote down, at Owen's request, the names of some of the best treatises for him to begin his studies with.

CHAPTER XVII.

THE MONSTER EYE.

WHEN it was dusk, the Astronomer led the boy to the top of the hill where the great telescope stood, and explained to him how it was merely a large pupil admitting some two feet, instead of a mere eighth of an inch, of light to the eye, and telling him how the longitude of stars was measured by time the same as the longitude of places on the earth. And when the tube was pointed to the moon, he let Owen peep through it and see the brilliant white disc shining through it like an immense plate of frosted silver.

As the boy gazed at the lovely orb, he could not speak, and scarcely breathed for wonderment. At first he could hardly believe he was looking on the moon, so vast did the image appear to him; but when he had assured himself of the fact, and the first feeling of amazement had in a measure subsided, he began to ask the Astronomer what the dark spots were supposed to be.

Then Mr. Blackwater charmed the lad still more by telling him that the spots on the surface of the orb were the shadows of mountains and the mouths of caverns; saying they were known to be such by the fact that when the sun was rising or setting to them the shadows became longer as they do with us on the earth; and as the sun's altitude increased to those parts their shadows grew shorter until the moon was full, when they disappeared altogether. Then the Astronomer pointed out to the enchanted boy a spot on the moon's disc that was called "Mount Newton," and another named "Mount Leibnitz," and "Autolycus," and "Aristarchus," and "Helvetius," and "Gassendi," telling him the while that from the measurement of the shadows to the lunar mountains, astronomers had found that the highest peak in the moon was 1¾ mile high. After this he ran over to the boy the names of the several large dark patches, telling him that the one near the western edge of the orb was called the "Crisian Sea," and that at the upper part of the eastern side the "Sea of Showers," while the one below it was termed the "Ocean of Storms;" though these, he added, are now known to be no seas at all, but merely immense plains that are less enlightened by the sun's rays. Next he drew the lad's attention to a chain of lunar mountains called the Apennines, and pointed out to him how the tops of all the peaks were shaped like cups, and were therefore supposed to be the craters of volcanoes.

In a few minutes the telescope was turned to *Saturn*, and the boy was shown the planet with its retinue of moons, and its broad ring with the shadow of it striping the body of the orb itself, which was likewise streaked with belts. Owen gazed with ecstasy upon the wondrous orb; and Mr. Blackwater told him the while how some of the old astronomers had fancied that the luminous girdle round Saturn was the tail of a comet, which the attraction of the orb had drawn to it and compelled to circulate about it; and how another astronomer had asserted that Saturn was originally as big as the outside of the ring itself, but that by some means the outer shell of the planet had been broken to pieces and fallen in upon the body, while the part of the shell at the equator remained entire, and so formed a ring about it; while a third had supposed that the ring was a part of the equator of the planet, which had been thrown off from it owing to the rate at which it turned round on its axis, in the same manner as water flies out from a mop that is rapidly trundled. Mr. Blackwater added, however, that we might as well attempt to account for the formation of *Saturn's* satellites as that of its ring; and that the wisest astronomers now-a-days could only say that the ring was created to answer some important purpose (since nothing was made uselessly), though what that purpose was, none had yet been able to discover.

After this the little fellow had a peep at *Jupiter* with his belts, and beheld the eclipse of one of those moons from which the velocity of light had been discovered; and, last of all, the telescope was directed to the *Milky Way*, and there the boy beheld that which before had appeared a mere wreath of luminous vapour resolved into such a profusion of stars, that he was overwhelmed with the splendour and beauty of the sight. As the lad still gazed with rapture at the mass of glittering orbs, Mr. Blackwater informed him that one who was the greatest astronomer, perhaps, that had ever lived, had calculated that a portion of the *Milky Way*—about 10° long and 2½° broad—contained no less than 258,000 stars; being so thickly strewn with worlds, that a disc the size of our moon would cover as many as 2000 of them at one time.

Whereupon Owen asked how many stars of the different magnitudes had been counted in the heavens.

Mr. Blackwater informed the boy that there were only about 20 stars of the first magnitude and but 60 odd of the second, while of the third there were about 200; and that as the stars got less in brilliance the numbers increased very rapidly, so that down to the seventh magnitude the whole number of stars that had been already registered amounted to nearly 20,000. "Beyond the seventh magnitude, however," he added, "the telescopic

stars—as those which are invisible to the naked eye are called—may be considered to be infinite in number, for there are spots in the heavens so thickly powdered over with orbs, that one might as well attempt to count the number of particles that make up the bloom on a plum, as to endeavour to bring the orbs which, in some parts, lie thick as motes in a sunbeam, within the compass of figures."

Then the Astronomer pointed out to the boy how, in those parts of the firmament where the stars were set far apart, there was always a dark background to be seen, and which, when the telescope was pointed to it, revealed no light or luminous mist shining in the far distance. He showed him, too, how, as we passed our eye along towards the *Milky Way*, the smaller stars became thicker and thicker about that part of the heavens, until in the *Milky Way* itself they were so condensed together, that even with the highest powers of the telescope it was impossible to separate them and see the dark background of infinite space frowning between them. "It was for this reason," he added, "that Sir William Herschel suggested that the universe of worlds, of which our system forms but a mere point, has a form and definite arrangement, of which the *Milky Way* is the luminous boundary encircling our sun and its little group of planets like an immense jewelled ring."

The night was now fast advancing, and Owen, though he could have stayed there for hours gazing through that wondrous tube at the glittering glories of the starry heavens, grew fearful lest those at home should become alarmed at his absence. Accordingly, the boy expressed his regret at being obliged to leave. The Astronomer, however, would not allow him to depart till he had shown him the figure that was now considered to be the shape of the universe; and when they had returned to the library, Mr. Blackwater took down a volume and displayed the annexed illustration to the lad's view.

"There, boy," said the philosopher, "you behold what is believed to be the form of the starry boundaries of the vast multitude of worlds with which the endless plains of space are set—thick as the sand in the Desert; for though some of these orbs may appear to our puny senses to lie millions and millions of miles apart from each other, to the All-seeing, it has been well said, 'the whole Universe may be as one plain, the distance between planet and planet being only as the pores in a grain of sand, and the spaces between system and system no greater than the intervals between one grain and the grain adjacent.'"

CHAPTER XVIII.

THE BOY LOSES HIS BEST FRIEND.

On the boy's return home he learnt from his father that poor old Captain Jones was not expected to live many hours, and that the doctor and lawyer had been with him all the evening. It was said in the village that Parson Wynn, too, had been sent for.

This was sorry and unexpected news to the little fellow; and though his mind during the ride home had been full of the wonders he had seen and heard, and he had busied himself in remembering the many marvellous things he had to tell his father and the Captain, as well as in fancying to himself how pleased the old sailor would be to hear that Mr. Blackwater had been so kind to him, nevertheless, when the lad was acquainted with the sad change that had taken place, his heart was so full of grief that he could think of nothing else.

Nor could the little fellow rest that night until he had gone towards the Captain's cottage and

assured himself that the light was still burning in the sick man's chamber.

The first thing, too, the boy did in the morning was to steal up again to the cottage, in the hope of gaining some tidings about his friend, and he loitered about to catch some one leaving the house, for he lacked the heart to go to the door.

After waiting about the gate some little while, Owen was delighted to see Betty Wynn come down the gravel walk, and no sooner did the girl catch sight of the little fellow, than she beckoned him hastily to her, saying, "she was just going up the village for him, as Captain Jones was anxious to see him once more."

The words "once more," sounded like a death-knell in the boy's ear, and the tears flooded his eyes and choked his speech, so that he said not a word, but held the girl tightly by the hand as she led him to the room.

Owen walked on tiptoe to the bedside, and looked upon the feeble old man through his tears.

The invalid raised his eyelids for a moment and smiled as he saw the little fellow standing by his side.

"Put your head near the pillow, Owey," whispered Betty, "he may wish to speak to you."

The lad did as he was bidden.

"Was Mr. ——— kind to you?" mumbled the

old man, as he waved his hand to show he could not recall the name of Blackwater.

Owen nodded assent, for he could scarcely speak. At length, however, he stifled his sobs sufficiently to whisper, "Very—very kind, sir."

"I am glad of it, for your sake, boy," muttered the invalid. "He can be a good friend to you when I'm gone;" and, as he said so, he raised his hand towards the boy.

"He wants you to take it," said Betty softly to the weeping lad.

Owen placed the old man's palm gently in his own, and bowing his head pressed it softly but fondly to his lips.

"Bless you! bless you!" said the old sailor in a faint voice. "You'll think of me, boy, *sometimes?* And you will study hard and be a great man one day—and you'll be good to little Peg, and watch over and protect her, as *I* would have done had God spared me."

The little fellow could only bow his head in reply.

"We shall meet again, Owen—again, Owen." The old man was too exhausted to say any more, and raising his finger pointed to the skies.

"You had better go now, Owey dear," said Betty in the boy's ear, "the doctor will be here directly. He has been staying in the village to be near at hand during the night."

The little fellow lingered, as he took what he felt would be a last look of his good friend, and Betty was about to drag him from the bedside, when she noticed the invalid's lips move again. "He has something else to say," she whispered to the boy.

Owen bent his head down to the pillow once more, and could just catch the sound of "I wish I was like you, boy, with a whole life before me, and all my deeds to perform over again. What fine things I'd do then! Think *you* of that—think *you* of that, and never do a thing you would wish undone in after life. Remember what I say, Owen,—*remember!*"

Betty at length led the sobbing boy from the room, and when he had quitted the cottage, he stole away to some unfrequented spot, and wept in secret over the kindhearted old man. All the day long, too, he kept returning continually to the cottage and inquiring of Mrs. Pugh, whenever he could catch sight of her, how the Captain was *then.*

At daybreak the next morning, the little fellow was off to the old sailor's cottage once more to learn from the housekeeper how he had passed the night.

At the gate stood Mrs. Pugh and old Betty Watkin, and Mrs. Pritchard, the labourer's wife, and little Mrs. Price, of the shop, and the clothier's tall dame, who had just run up from the mill. And

as the boy caught sight of the group, his heart sank in his bosom.

Then as he glanced up at the window of the sick man's chamber he beheld the shutters closed, and he knew in a moment that he had lost his best friend.

CHAPTER XIX.

THE FIRST AND LAST LAW.

The old sailor was laid in the patch of ground adjoining the little mountain church; and the day of his burial was the saddest that had long been known at Llanvach. The village children, to whom his kindness to the young had long endeared him, all followed the coffin to the grave; and the parents were there too, for they had long loved the old man for his love of their little ones.

But of all the sad throng, Owen Evans was the saddest, and, in obedience to the Captain's last request, he and his little sister Peg headed the funeral train.

When the band of mourners had returned to the tenantless cottage, the lawyer from Builth proceeded to read the will of the departed man. Nor was Mrs. Pugh absent from the listening company, for she was all anxiety to learn how her late master had provided for her, and almost assured herself—

as the Captain had no one belonging to him in the world—that the whole or greater part of his property would come to her, for she could understand no prior claim to her own.

To the dame's utter astonishment, however, she found that the old gentleman had bequeathed her only a year's wages beyond the quarter due to her, while the bulk of his little property, amounting to some 400*l*. a year, he had left to Parson Wynn and Mr. Blackwater, in trust for his "adopted children," Owen and Peggy Evans. He had made, too, a special request to Mr. Blackwater, in the document, that he would watch over the boy and direct his education. While to the Parson's daughters he willed a small annuity, as a remuneration for their future care of little Peg.

On the evening of that day, Owen, who had returned home with Mr. Wynn, sat with him at the chimney corner of the Parsonage, talking over the many kindnesses the Captain had done him, when the clergyman, thinking it a fit opportunity to impress the lad with some of the high truths that mere physical science cannot teach directly—though it may enable the mind to reason the more surely about them—took occasion to ask the boy whether he had ever thought as to what proofs there were concerning the existence of the soul after death.

The lad confessed he had never done so, adding that he should much like to hear them.

"Well," said the Parson, "it is the first law of force, that a body once set in motion by it will go on for ever—unless there be some *external* cause to stop it. A ball projected into space would roll on to all eternity, in the same direction as that in which it was originally impelled, were there nothing beside it to alter its course, or retard its progress."

"Would it, sir?" was all the boy said; for Owen's heart was still too full to talk, though he was glad to listen in order to divert his thoughts.

"Yes, Owen, it would," went on the clergyman, "for no force diminishes or dies of itself; that is to say, there is no principle of decay or death within it, and *to cease, it must be operated upon by external causes.* Bodies in motion on the earth are brought to a state of rest by the operation of forces antagonistic to their own—such as the resistance of the air, and the friction of the substances over which they pass; but, could these be destroyed, they would continue moving to the end of time. The earth, however, in its rotation on its axis, meets with no such impediment, and the consequence is, that its rate of motion is the same now as it was centuries ago; for each day measured by the passages of the stars is found to be so precisely of the same length that, according to the calculations of Laplace—

one of the most profound among mathematicians—it is impossible that a difference of 100th of a second of time should have obtained between the duration of the days in the earliest ages and those of the present era."

"Indeed, sir!" briefly remarked the melancholy lad.

"So you see, my boy," proceeded Mr. Wynn, "a force, once generated, has a tendency to continue for ever without decay of its power, and would so continue, were there nothing external to itself to diminish or destroy it."

"Yes, I see, sir," added the boy.

"Well," continued the Parson, "life in its vegetative quality is a mere force of accretion—a subtle and mysterious power that enables the living body to collect to itself those elements that are fitted for its nutrition, and to assimilate them with its own substance; while human life consists not only in the accretion of material particles but of experiences and intuitions. That is to say, as our bodies are made up of a collection of solid atoms, which the vegetative force has drawn to itself, so our minds consist of an aggregation of ideas and emotions derived from the operations of the spiritual force, and connected together, so as to form a distinct individual consciousness. Now there is a law appertaining to our mental constitution that is as won-

derful as any of those regulating the world without us; for the same sequence of cause and effect as prevails in external nature is also found to obtain in the world within us. This is what is called *the law of the succession of ideas;* and strange as it may sound to you, Owen, not a thought starts unbidden to the mind, which is not the consequence of some other thought or feeling that has immediately preceded it, and which, in its turn, suggests or calls up another; and so the train of memories, reasonings, and fancies is carried on. It is a necessary result then of this principle of the *causation of thought,* or the natural tendency of one conception to excite in the mind another that is associated with it, either in time, or in place, or that is like or opposed to it—I say it is a necessary result of this principle that the sequence of ideas should continue for ever (in the same manner as the motion of a sphere once projected in space would go on to all eternity) *unless there be some external cause to stop it;* for the mental force has, like the other, no principle of death or decay within itself, but rather contains the elements of endless progression."

The boy nodded assent.

"The question then becomes, my little man," added Mr. Wynn, "what cause is there for the stoppage of the operation of this mental principle when once started in a human being? Can *death* put an end to it?"

Owen looked anxiously at the clergyman as he

awaited his answer, though the word brought the tears again to his eyes.

"Let us see," continued Mr. Wynn, "what occurs at such a time, *asserting nothing farther than the facts will strictly warrant.* Death, then, is the cessation of vegetative existence; that is to say, the force of accretion which enabled the body to collect and assimilate to itself the substances that were fitted for its nutrition has come to an end—been stopped by some external cause—and no longer has the power to prevent the chemical forces without from resolving the atoms, of which that body is made up, into their parent gases and dust. With us, however, death is something still more than this; for that same body was fitted with many wondrous organs, by which the being within was rendered susceptible of being affected by the things outside of him, and of affecting them in return. He could see, hear, feel, and have every other evidence his senses afforded him of the existence of external objects; and, moreover, he could move his limbs, and express his thoughts at will. But in death, this faculty of sensation and muscular action being derived from the organs that formed part of his body, ceased with the force that held the particles of that body together; and accordingly the being, whom we have known while living, has, when the vital functions have ended, no longer the power to look upon us, or hear our voice, or feel the pressure of our hand;

neither can he talk to us, nor by the motion of his muscles evince any signs of pleasure or pain. In sleep, the same insensibility to external objects prevails, though to a less degree; still we know that in our dreams during that state the succession of thought *may* continue, even when outward consciousness has ceased. This, then, *adhering strictly to the facts, and asserting no more, as I said before, than the circumstances will warrant*, is all that we can state of death —the spirit, which during life was capable of being affected by, and of affecting external objects, through the organs of the body, is no longer able to hold communion, by such means, with the world without, when the force that held together the particles of that body has come to an end. Can we then, consistently with the rules of strict reasoning, assert that, because the force which bound the material atoms into one frame has been dissipated, therefore the other force, which linked the ideas into one individual consciousness, has been destroyed? Now it cannot be said that these two forces are one and the same, or that the principle of the association of ideas is identical with that of organic existence; for the laws which link thought to thought are *in no way connected with the organs of the body, but proceed from the very nature of the ideas themselves*—since one conception calls up another in the mind, because, as I have said, it is *associated* with the other by some peculiar relation, and *not from any* ORGANIC

*connexion between them.** The law of the sequence of thought, therefore, is a separate and distinct law from that of mere organism, being the law of spiritual life, and the other that of pure material existence; while the spiritual law contains within itself no element of cessation, but rather that of endurance to all eternity."

"But, Mr. Wynn," asked the boy, "do we always think?"

"Perhaps not," answered the minister, "for it is but natural that these two forces being knit together in the same frame, the one should operate upon, and impede the functions of the other; for as two opposing forces produce rest, it is quite possible that the organic force may, in certain states of

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* That organism is necessary for the original production of sensations and ideas, there cannot be the least doubt. Those who are born deaf, or blind, can have no notion of sound or colour, for wanting the organ upon which the ideas primarily depend, the mind has no power to form any conception of such things. But though organism is necessary for the original *production* of impressions, it is by no means necessary for the *re-production* of them. BEETHOVEN composing his finest music, after he had lost his hearing, is overpowering evidence of this; proving to us that, though the organ on which the faculty originally depended was dead, the soul of the musician contained within itself the principle of reproducing the impressions divested of any such organic apparatus. If then it be possible for the soul to revive the ideas derived from *one* organ, after that organ is destroyed, why cannot the soul recal the impressions of *every other* organ when the *whole* organic arrangement of our bodies is at an end?

the body, be so far in antagonism with the spiritual power as to bring it into abeyance for the time being. Accordingly, in states of what is called '*coma*,' or perfect insensibility, we have no evidence of the mind being in operation; though at the same time we have no evidence that it is *not* in operation. But, even admitting that the succession of ideas *is* broken and stopped during certain conditions of the body, still this affords us no proof that such an effect occurs at death, but is rather an evidence that, when the control of the organic force is at an end, the spiritual power will continue with increased energy. For two opposing forces can only produce rest, *while each of them remains in operation*, but destroy or remove one—and the other must instantly start forward on its destined course, with all the energy that was originally impressed upon it by the Prime Mover. Even as the bow that, when strained back by the strong arm of the archer, remains bent so long as the greater force is upon it; but immediately the archer's grip is relaxed, it springs again into its original state, speeding the winged arrow far into the skies. Or, look here, boy," added the Parson, "I press a finger of each hand hard against one another, and let me use what force I will, a state of mere rest is the consequence; but remove the one which controlled the action of the other, and away that other darts with all the power that I had impressed upon it. So you see, lad, though it is quite

possible for the body to impede the action of the spirit, even so far as to make it appear to be altogether dead and inert, still, take away the opposing force of that body, and then the spirit must instantly fly from it, quickened with all the impulses that were originally given to it by the Great Power above."

CHAPTER XX.

CONCLUSION.

NOT long after the incidents detailed in the foregoing chapters, Owen Evans took up his abode in Mr. Blackwater's house, so that his education might be conducted under the eye of the philosopher, who had grown, by closer acquaintance with the boy, to entertain so high an opinion of his genius, and to have such great hopes of his adding one day to the circle of knowledge, that, in compliance with the Captain's last request, Mr. Blackwater deemed it better that the lad should remain under his roof until the tutor he engaged for him had fitted him for the higher course of studies at one of the Universities.

Little Peggy, his sister, was removed to the Parsonage, where Betty and Lucy Wynn watched over the child with all the tenderness of which their gentle natures were capable; whilst Davy Evans, whom Owen had sufficiently provided for out of his

portion to enable to cease work, had gone to live at a cottage near the Wynns, where he amused himself with his lathe, making toys for the little ones round about, and turning needle-cases and tobacco-stoppers, and rolling-pins, for his friends, and bowls and skittles for the villagers.

Nor must John Jarman, the blacksmith's boy, be forgotten. At the end of his first voyage he returned to Llanvach with his "pay," and this was just sufficient to rescue the forge that was about to be sold for rent, and to save his mother from being deprived of her home; for since the boy's departure the intemperate habits of his father had grown worse—indeed, the lad found his parent a mere wreck of a man from his continual indulgence in drink. The blacksmith boy is now master of the village forge, mending the ploughs and making new tires for the wheels of the wagons, and shoeing the cart-horses, for miles round—not forgetting "Jessie," the Parson's mare, and "old Jack," the donkey, who now share together, it should be added, the grass and windfalls from the apple-trees in Parson Wynn's orchard.

Owen, in his new life, did not fail to remember his friend the clothier, and his former master, farmer Powell of the hills; for whenever he could steal time enough from his studies, he would pay a visit to the mill and listen, with as much delight as ever, to Roger Wilkins's stories about inventions and discoveries; and then hurry on to the

mountain farm, where there was no more welcome visitor, and where the simple-minded farmer and his girls would sit agape with wonder as they made the lad tell them all he had been doing about the stars of late. Nor did the old farmer fail to exclaim as usual, when the boy had taken his departure, "*Her* will be a wonderful man some day—*her* will."

THE END.

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